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ABSTRACT

Research and Development is a laboratory-oriented course that includes the appropriate common essential elements for industrial technology education plus concepts and skills related to research and development. This guide provides teachers of the course with learning activities for secondary students. Introductory materials include an instructional planning outline and worksheet, an outline of essential elements, a list of domains and information on creativity and problem solving, student projects, and research notebooks. The guide contains 34 modules on the following topics: documentary project; journal/sketchbook; research funding foundation; field notebook; basic principles of research; problem-solving module; brainstorming; imitation, adaptation, and innovation; writing a technical paper; technical research report writing; designing technical data posters; problem identification; analyzing specifications; developing a solution; pilot-testing the solution; analyzing the results; time line; computing personalized development times; designing an airport plan with facilities; making a standard color negative; studio photography; video production; newsletter; aerodynamics of flight; sketching a glider design; drawing glider plans; building a glider prototype and analyzing the design; implementing the final design; model wind tunnel; solar-assisted vehicle; engineering a model building; truss design and testing; designing and fabricating an aluminum can crusher; and estimating structural materials. Each module includes an instructor's resource sheet and the student laboratory activity. Each instructor's resource sheet may include the following elements: module number; activity topic; estimated time; essential elements; objectives; activity summary; teaching tips; instructional strategy; equipment/supplies; evaluation key; and support materials. Each student activity may include the following elements: module number; activity topic; activity overview; objectives; vocabulary/concepts reinforced; equipment/supplies; introduction; procedure; evaluation; and support materials. (NLA)

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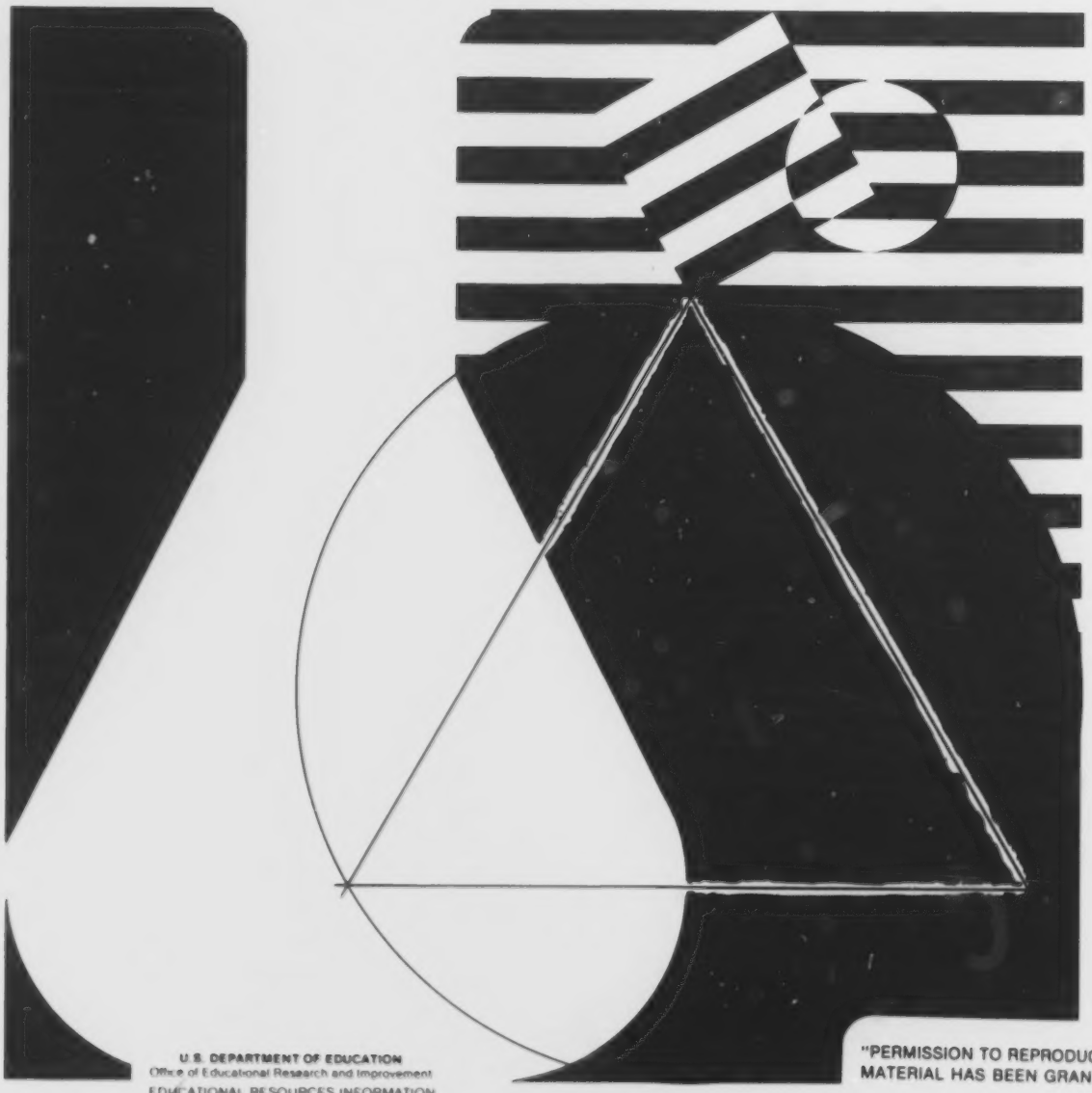
Research and Development



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Research and Development

Laboratory Activities

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Organization of the Laboratory Activity Materials

The major portion of the guide is the compilation of laboratory activity modules. The laboratory activity modules were developed, tested, and reviewed by technology teachers, supervisors, and teacher educators.

Each module includes (1) an instructor's resource sheet and (2) the student laboratory activity.

Each instructor's resource sheet includes the following elements where appropriate:

- Instructor's resource sheet module number
- Activity topic
- Estimated time
- Essential Elements (common and specific)
- TAAS Objectives
- Activity Summary
- Teaching Tips
- Instructional Strategy
- Equipment/Supplies
- Evaluation Key
- Support Materials

Each student activity includes the following elements where appropriate:

- Student activity module number
- Activity topic
- Activity overview
- Objectives
- Vocabulary/Concepts Reinforced
- Equipment/Supplies
- Introduction (to the activity)
- Procedure (step by step)
- Evaluation
- Support Materials

Using the Laboratory Activity Materials

Intended Audience: The material in this guide is designed for use by technology teachers and students in grades nine through twelve. Many of the modules, however, would also be appropriate and recommended for use by junior high/middle school technology programs.

Length of Time for the Materials: The topic of study has been developed to provide materials for 18 to 36 weeks of study. Each module includes a suggested time frame for completion of the activity/module.

Benefits for Teachers and Students: The materials included in this guide were developed to assist technology teachers in planning, organizing, teaching, implementing, and evaluating a technology-based instructional program. The broad exposure students will receive by being involved in the laboratory activities in this guide will enhance their total educational program experience, including their problem-solving skills, creative thinking skills, and social interaction skills, as well as communication, computation, and technical skills.

Flexibility of the Materials: This guide, like other curriculum materials, does not attempt to encompass all situations. Therefore, teachers should supplement the guide with other appropriate ideas, information, and activities as needed in their particular programs.

A key feature in this guide is flexibility. The material may be used in the context of a large class/group approach, a small group approach where appropriate, and, in many of the modules, an individualized approach. In some of the modules, a combination of all three approaches might be incorporated.

Modules should be selected by the teacher in the order that he or she chooses, and the teacher is encouraged to expand or condense the student laboratory activity to meet the needs of addressing essential elements and the time frame designated to cover the topic. Teachers may also need to make substitutions in the use of each module, depending on the equipment, resources, and/or reference materials available.

Essential Elements/TAAS Objectives: Essential elements and TAAS objectives for reading, writing, and mathematics have been identified in each module (where appropriate). As used in this guide, essential element statements represent skills, knowledge, and/or attitudes that imply the ability or intelligence to accomplish an idea, problem, task, job, etc. Essential element statements will assist the teacher in clearly formulating the scope and sequence of the course of study and the purpose and processes for student learning.

Instructional Planning: An instructional planning outline and worksheet are included in the guide for teachers to use in their planning and preparation. The outline and worksheet should prove beneficial to teachers in enhancing their use of various instructional practices, in identifying appropriate teaching behaviors and process decisions, and in documenting teaching techniques selected.

Instructional Planning Outline

Domain I. Instructional Strategies

Criterion 1. Provides opportunities for students to participate actively and successfully

Indicator:
a. appropriately varies activities
b. interacts with students in group formats as appropriate
c. solicits student participation
d. extends students' responses/contributions
e. provides ample time for students to respond to teacher questions/solicitations and to consider content as it is presented
f. implements instruction at appropriate level of difficulty

Criterion 2. Evaluates and provides feedback on student progress during instruction

Indicator:
a. communicates learning expectations
b. monitors students' performances as they engage in learning activities
c. solicits responses or demonstrations from specific students for assessment purposes
d. reinforces correct responses
e. provides corrective feedback, or none needed
f. reteaches, or none needed

Domain II. Classroom Management and Organization

Criterion 3. Organizes materials and students

Indicator:
a. secures student attention, or students are attending
b. uses administrative procedures and routines which facilitate instruction
c. gives clear administrative directions for classroom procedures or routines, or none needed
d. maintains seating arrangements/grouping appropriate for the activity and the environment
e. has materials, aids, and facilities ready for use

Criterion 4. Maximizes amount of time available for instruction

Indicator:
a. begins promptly/avoids wasting time at the end of the instructional period
b. implements appropriate sequence of activities
c. maintains appropriate pace
d. maintains focus
e. keeps students engaged

Criterion 5. Manages student behavior

Indicator:
a. specifies expectations for class behavior, or none needed
b. uses techniques to prevent off-task behavior, or none needed
c. uses techniques to redirect off-task behavior, or none needed
d. uses techniques to stop inappropriate behavior, or none needed
e. uses techniques to stop disruptive behavior, or none needed
f. applies rules consistently and fairly
g. reinforces appropriate behavior when appropriate

Domain III. Presentation of Subject Matter

Criterion 6. Teaches for cognitive, affective, and/or psychomotor learning and transfer

Indicator:
a. begins instruction/activity with an appropriate introduction
b. presents information in an appropriate sequence
c. relates lesson content to prior or future learning
d. provides for definition of concepts and description of skills and/or attitudes and interests
e. provides for elaboration of critical attributes of concepts, psychomotor skills, and/or attitudes and interests
f. stresses generalization, principle, or rule as a relationship between or among concepts, skills, and/or attitudes/interests
g. provides opportunities for transfer
h. closes instruction appropriately

Criterion 7. Presents information accurately and clearly

Indicator:
a. makes no significant errors
b. uses vocabulary appropriate to students
c. explains content and/or learning tasks clearly
d. stresses important points and dimensions of content
e. clarifies student misunderstanding, or none needed

Criterion 8. Uses acceptable communication skills

Indicator:
a. uses correct grammar
b. pronounces words correctly and clearly
c. uses accurate language
d. demonstrates skill in written communication

Domain IV. Learning Environment

Criterion 9. Uses strategies to motivate students for learning

Indicator:
a. relates content to student interests/experiences
b. emphasizes the value/importance of the activity or content
c. reinforces learning efforts of students
d. challenges students

Criterion 10. Maintains supportive environment

Indicator:
a. avoids sarcasm and negative criticism
b. establishes climate of courtesy and respect
c. encourages slow and reluctant students
d. provides praise for specific performance
e. establishes and maintains positive rapport with students

Domain V. Growth and Responsibilities

Criterion 11. Plans for and engages in professional development

Indicator:
a. shows progress in completing professional growth requirements as agreed upon with appraiser(s), or none needed
b. stays current in content taught
c. stays current in instructional methodology

Criterion 12. Interacts and communicates effectively with parents

Indicator:
a. initiates communications with parents about student performance and/or behavior when appropriate
b. conducts parent-teacher conferences in accordance with local district policy
c. reports student progress to parents in accordance with local district policy
d. maintains confidentiality unless disclosure is required by law

Criterion 13. Complies with policies, operating procedures, and requirements

Indicator:
a. follows statutory and Texas Education Agency regulations
b. follows district and campus policies and procedures
c. performs assigned professional duties
d. follows district promotion/retention policy and procedures

Criterion 14. Promotes and evaluates student growth

Indicator:
a. participates in campus goal-setting for student progress
b. plans instruction in accordance with district requirements
c. documents students progress
d. maintains accurate records
e. reports student progress at appropriate intervals

Instructional Planning Worksheet

Essential Element(s): _____

TAAS Objective(s): _____

Curriculum Guide Page: _____

Objective: At the conclusion of the lesson, the learner will be able to:

_____

_____

_____

_____

Focus Activity: _____

_____

_____

a. Task for lesson _____

_____

b. Value of lesson to learner is _____

_____

Explanation / Check Understanding:

a. ☐ Lecture ☐ Overhead ☐ Demonstration ☐ _____

b. ☐ Curriculum Guide page _____ ☐ Text page _____ ☐ _____

c. Modeling (teaching will) _____

_____

_____

d. Key questions to check understanding:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Guided Practice Exercise:

☐ Exercise copied from overhead ☐ Handout worksheet No._____

☐ Copy from board ☐ Read sample problems ☐_____

_____

_____

Checking Mastery: (learning progress)

☐ View each student's work ☐ Students check and signal correct

☐ _____

_____

Independent Practice: (reteach those needing help while others work)

☐ Worksheet No._____ ☐ Copy from overhead ☐ Copy from board

☐ Copy as dictated ☐ Reteach worksheet/outline number _____

☐ _____

☐ _____

Extension: (enrichment/application)

☐ Worksheet No._____ ☐ _____

Describe how this activity makes relevant application of the lesson: _____

_____

_____

_____

Closure: Restate the learning: _____

_____

Method to involve the learner in the summary: _____

_____

Sponge Activities: Sponge Focus Activity No._____

Other Sponge Activity No. _____

Essential Elements
Common to All Industrial Technology Programs

75.85 The elements in this subsection are common to all industrial technology education courses, Grades 9-12, unless otherwise indicated and shall be included in each course at the appropriate level. They are described here to preclude repetition in each course. Every school offering industrial technology education shall provide courses which include the following essential elements.

1. Leadership concepts and skills. The student shall be provided opportunities to:

   A. demonstrate skills, characteristics, and responsibilities of leaders and effective group members;
   B. demonstrate a knowledge of parliamentary procedure principles;
   C. plan and conduct leadership activities; and
   D. prepare for effective citizenship and for participation in our democratic society.

2. Concepts and skills related to successful employment and/or postsecondary training. The student shall be provided opportunities to:

   A. identify employment opportunities and preparation requirements in chosen fields;
   B. identify effective methods to secure and terminate employment;
   C. demonstrate effective communication skills both oral and written and follow through on assigned tasks;
   D. demonstrate dependability and punctuality;
   E. demonstrate productive work habits and attitudes;
   F. understand the importance of taking pride in the quality of work performed;
   G. recognize the dignity in work;
   H. develop skills in planning and organizing work;
   I. apply required methods and sequences when performing tasks;
   J. apply principles of time management and work simplification when performing assigned tasks;
   K. identify ethical practices and responsibilities; and
   L. understand the importance of the application of organizational policies and procedures.

3. Concepts and skills associated with entrepreneurship. The student shall be provided opportunities to:

   A. identify opportunities for business ownership;
   B. understand the risk and profit motive factor;
   C. understand the elements and advantages of the free enterprise system; and
   D. explain the role of small business in the free enterprise system.

4. Concepts and skills associated with human relations and personality development. The student shall be provided opportunities to:

A. understand the importance of maintaining good health and proper appearance for effective job performance;
B. understand oneself and others;
C. exercise self-control;
D. accept and use criticism;
E. recognize basic human relationships as they relate to business success; and
F. demonstrate characteristics for successful working relationships.

5. Concepts and skills related to personal and business management. The student shall be provided opportunities to:

A. explain how management assists in reaching personal and family goals;
B. explain the management process;
C. describe the role of management in controlling stress;
D. identify and understand personal checking accounts;
E. identify and understand personal loan application processes;
F. identify and understand different financial institutions;
G. identify the role and functions of business management;
H. understand the lines of authority; and
I. identify effective supervisory techniques.

6. Concepts and skills related to the application of safety practices. The student shall be provided opportunities to:

A. demonstrate safe operation of appropriate tools, machines, and equipment;
B. maintain a safe and clean laboratory environment; and
C. investigate appropriate state and federal safety laws.

7. Concepts and skills related to social/cultural impacts of technology. The student shall be provided opportunities to:

A. investigate ideas and technological developments of the past and present;
B. assess the characteristics of technological change on society and culture;
C. predict how selected technological developments will impact future cultures and societies; and
D. explore the impact technology has on the environment.

8. Concepts and skills related to the application of technology to daily life. The student shall be provided opportunities to:

A. evaluate selected products based on given standards or applications;
B. develop criteria for selecting, purchasing, and contracting services;
C. practice the servicing of selected products and equipment of technology;
D. investigate the interrelationship of all technology areas;
E. use computer-controlled systems and/or devices related to each course; and
F. apply the design process to product development.

9. Concepts and skills related to the tools, materials, and processes of technology. The student shall be provided opportunities to:

A. become proficient in the use of appropriate tools, machines, and equipment;
B. analyze the properties of a wide range of materials of technology through testing;
C. explore the processes of various technologies; and
D. investigate and practice conservation and recycling of products and materials of technology.

10. Concepts and skills related to the application of problem-solving techniques. The student shall be provided opportunities to:

A. identify and creatively solve technological problems using the scientific method;
B. explore standards of measurement used in technology and apply measurement in the solution of problems; and
C. communicate oral, written, and computational technical information.

Research and Development Essential Elements

Research and development is a laboratory-oriented course that includes the appropriate common essential elements for industrial technology education, plus concepts and skills related to research and development. The student shall be provided opportunities to:

1. identify the methodologies of basic and applied research;
2. utilize the scientific method for problem solving;
3. utilize the input/process/output/feedback model;
4. distinguish between imitation, adaptation, and innovation related to industrial products and processes;
5. apply human engineering factors;
6. design or improve products or processes to meet stated performance standards;
7. organize technical data for graphic presentation;
8. build experimental models, mock-ups, or prototypes as appropriate;
9. identify quality control tests;
10. investigate the economic impact of the researched solution; and
11. develop a technical report following accepted research format.

Texas Assessment of Academic Skills (TAAS): Domains and Objectives

ENGLISH LANGUAGE ARTS
GRADES 3, 5, 7, 9 AND EXIT LEVEL

DOMAIN: *READING COMPREHENSION*

OBJECTIVES:

The student will:

1. determine the meaning of words
2. identify supporting ideas
3. summarize written texts
4. perceive relationships and recognize outcomes
5. analyze information to make inferences/generalizations
6. recognize points of view, propaganda, and/or fact and nonfact

DOMAIN: *WRITTEN COMMUNICATION*

OBJECTIVES:

The student will:

1. respond appropriately to the purpose/audience in a written composition
2. organize ideas in a written composition
3. demonstrate control of the English language in a written composition
4. generate a written composition which develops and supports a central idea
5. recognize appropriate sentence construction
6. recognize appropriate word usage
7. recognize within the context of a written passage:
   (a) the correct spelling of words
   (b) correct capitalization
   (c) appropriate punctuation

MATHEMATICS
GRADES 3, 5, 7, 9, AND EXIT LEVEL

DOMAIN: *CONCEPTS*

OBJECTIVES:

The student will:

1. demonstrate an understanding of the concepts of numbers
2. demonstrate an understanding of mathematical relations, functions, and other algebraic concepts
3. demonstrate an understanding of geometric properties and relationships
4. demonstrate an understanding of measurement concepts using metric and customary units
5. demonstrate concepts related to an understanding of probability and statistics

DOMAIN: *OPERATIONS*

OBJECTIVES:

The student will:

1. demonstrate skills, concepts, and applications related to addition
2. demonstrate skills, concepts, and applications related to subtraction
3. demonstrate skills, concepts, and applications related to multiplication
4. demonstrate skills, concepts, and applications related to division

DOMAIN: *PROBLEM SOLVING*

OBJECTIVES:

The student will:

1. estimate solutions
2. analyze problems and identify solution strategies
3. express problems using mathematical representations
4. evaluate the reasonableness of problem solutions

Research and Development
Course Description and Content Outline

9-12 Grades, 1/2-1

Research and Development is an activity-based course that provides students the opportunity to do research and development activities in any one or more of the technology areas of communication, energy, and production. A student or small group of students is able to creatively pursue new knowledge and solve technological/industrial problems. Students do research, data collection, problem solving, designing, developing prototypes, and making working models. Examples of student learning activities are: constructing prototypes, conducting market research, making working drawings with computers, conducting computer simulations, designing and engineering products, and preparing technical reports, A controlled internship may be considered as part of the research and development experience. Examples of equipment used are: computer hardware/software, computer-aided drafting (CAD) systems, and appropriate equipment related to the technologies of communication, energy, and production.

Essential Elements	Suggested Content Outline	Suggested Learning Activities
	I. Introduction	
	A. Overview	
	1. What is research and development (R&D)?	View "Connections" by James Burke. Apply heat to latex rubber—illustrates accidental discovery. Bell circuit/components hidden = trial & error
	2. Research and development in industry and technology	Bulletin board collection of drawings, photos, or names of certain inventors
	B. Orientation to Research and Development	Collect and discuss examples of basic and applied research.
75.85.159	1. Types of research	
	a. Basic	
	b. Applied	
75.85.162	2. Technical research processes	Discuss examples of research processes. List 10 processes/products that have been improved by R&D. Collect newspapers/periodicals to locate articles that illustrate new processes/products. Brief description entered in computer.
	a. Imitation	
	b. Adaptation	
	c. Innovation	
	II. Research and Development System	
	A. Research	
	1. Identify and state the problem	Identify possible problems.
	2. Review	Identify correct library procedures and location of materials.

		Discuss possible resources—students use computer to write for information.
	3. Plan for research	
75.85.160	a. Techniques of problem solution	Present problems to be solved individually and in group.
	(1) Scientific method	
	(2) Brainstorming	Brainstorm list of potential problems or ideas.
	(3) Research planning	Students identify research plan to bring problem to final conclusion. Develop procedural plan—delegate (if group) responsibility to carry out parts of plan.
75.85.161	b. Selection of problem solution, i.e., input/process/output/feedback model	Develop flowchart for research process.
	c. Procedures of data collection	Identify ways of collecting data.
	d. Feasibility of research problem	Select problem for research and development.
	B. Development	
	1. Statement of problem	Write problem and begin research.
	2. Designing	
	a. Ideation/problem solving	Develop a conclusion based on all info gathered. Make oral presentation to class using visuals. Use Section II.B. to develop and engineer a problem solution.
	b. Sketches/drawings	
75.85.168	c. Financial feasibility	
75.85.164		
75.85.167	d. Quality assurance considerations	
	3. Experimentation	
	a. Mock-up	
	b. Breadboard	
	c. Testing	
	d. Redesign	
75.85.163	e. Human engineering factors	
75.85.6	f. Safety	
75.85.166	4. Configuration of results	
	a. Evaluation and decision	
	b. Prototype development	
	c. Pilot model development	
	d. Production of final model	
	e. Marketing	
75.85.169	III. Reporting the Final Results	Write a technical report to document research project and defend to class.
	A. Organizing the results	
75.85.165	B. Graphics representations	
	C. Written technical research reports	
	D. Oral report	

Creativity and Problem Solving in Industrial Technology Education

The scope of this Research and Development guide is to provide teachers with a useful instrument that will generate learning activities for students at any level. The intention of the activities contained in the guide is to help develop creative thinking and problem-solving skills through a variety of individual and group activities. Several types of activities are included in each of the instructional areas as well as some general research and development projects which can be applied to any area of Industrial Technology Education.

It is understood that the Research and Development course may be taught as a stand-alone class or included in a stacked class containing one or more levels of students. Whatever the method of organization, the research and development concept provides teachers and students an opportunity to work together in a very exciting learning and instructional environment. The idea of teaching RESEARCH and DEVELOPMENT concepts in a technological area is to provide both teachers and students with an avenue for greater individual growth and development.

One of the most important components of the new Industrial Technology Education curriculum is the development of problem-solving and creative thinking skills in our students. These concepts are emphasized in this activity guide and will be an important part of the Research and Development course. For many Industrial Technology Education teachers, these concepts are not new, and these teachers will be able to use the activities in this guide as a springboard from which to create challenging learning experiences for their students.

The approach in the past has generally included instruction through developing a knowledge of processes, materials, and tools. The scope of this activity guide includes these concepts but also includes a potentially more effective set of instructional processes, creative thinking and problem solving. These two components dovetail nicely into the Industrial Technology Education concept and may prove to be the most important concepts in our new curriculum.

Creative thinking and problem solving can be seen in the same light. As they are presented in this activity guide, *creative thinking* refers to a general attitude toward problem solving. *Problem solving* refers to a systematic approach to solving technical problems. An example of the combined use of these two concepts is an activity that asks students to develop a modularized school facility system which uses mobile modules (classrooms, hallways, offices, restrooms, etc.) that can be moved from one school site to another and plugged in for use. The idea is to develop the ultimate "portable" school. This type of activity requires a systematic approach as well as creative thinking to solve the problem.

As you review the various activities contained in this guide, you will see how problem-solving skills are presented. Basically they include the following:

A. Problem identification
B. Evaluation of specifications
C. Development of solutions
D. Selecting the best solution
E. Utilizing the solution
F. Observing the results and comparing them to the initial problem goals

The Industrial Technology Education lab is an ideal facility in which to teach problem-solving and creative thinking skills. As industrial technology educators, we have the practical knowledge of processes, materials, and equipment to facilitate this type of instruction. Some of the instructional strategies that you will find useful include the following:

A. Encourage a systematic approach to the problem-solving activity.
B. Use small group activities and encourage teamwork whenever possible.
C. Encourage group brainstorming and have students express their ideas verbally. Be careful not to belittle or discourage creative thinking.
D. Use activities that are relevant to what your students are interested in.
E. Emphasize the process rather than the product in your instruction.
F. Use modeling and simulation where appropriate.
G. Problem solving should be an active process with the teacher acting as the catalyst to motivate students.
H. Be enthusiastic with your instructional approach; enthusiasm is contagious.

Some of the most powerful essential elements covered by all areas of Industrial Technology Education are those of problem solving and creative thinking. These concepts are real lifetime skills and will certainly benefit our students as they graduate from our programs into the world of work or academia.

RESEARCH AND DEVELOPMENT PROJECTS

Alternative Lighting System
This project began with the renovation of a small storage building. An office was built inside the building and, because no electricity was available, an alternative lighting system was needed. The problem was to design a lighting system that was inexpensive and required no AC electricity. Also, because the building was a wood frame structure and adding windows, skylights, etc., was being considered, the security of the building was a problem. Three major areas were researched: sources of power (wind, solar, battery, etc.); types of lights (incandescent, fluorescent, etc.); and structural alternatives (skylights, windows, etc.). After data was gathered, several different options were proposed. Tests were run to determine the efficiency of these options. One such test was to power lights with a battery and compare the data with that of lights powered by a battery recharged by a solar cell. After testing, the proposals were evaluated on the basis of several different criteria such as effectiveness, efficiency, cost, and security. An optimal solution was chosen for presentation to the school administration.

Photographic Film Dryer
The project started with a complaint in the photography department about the time required to dry photographic film. Based on the characteristics of commercially available cabinet film dryers, a prototype of an improved version was considered. Before design of the actual product was considered, several tests were run to make sure the photographic film was not damaged in any way. Using a hair dryer with several heat settings, students tested several different types of film for heat resistance. The temperature of the air produced by the hair dryer and the time of exposure were recorded to determine when damage to the film might occur. Several designs for the cabinet were made, with special attention paid to the heat source and air currents inside the cabinet. The heat elements from hair dryers and heat guns were used as heat sources. Several different fans and baffle systems were tested to create an optimum airflow quantity and pattern in the test cabinet.

Plastic Backpack Frame
This project evaluated existing types of metal backpack frames and used the results to design a plastic frame. Two major improvements were to be considered in the design. First, the plastic frame would flex with the back as different types of motion were encountered. Second, a set of supports would be included to help remove the weight from the shoulders and place it on the hips of the wearer. This project required much research into plastics and its characteristics, how plastics are formed, how plastics are fastened, etc. Several different scale models were made to illustrate different designs. These designs were evaluated and a full scale prototype was produced.

Water Circulation in a Spa
The purpose of this project was to locate the water jets in a spa to produce the maximum circulation with a minimum number of jets. The first step was to choose a spa for a model. This was arbitrary. A scale model of the spa was made with Styrofoam covered with plaster of paris. Next, the jets used in spas were researched. The jet to be used in this design was chosen because of its ability to produce a large conical area of motion in the water. This was achieved through a set of directional fins that rotated as the water was forced through the jet. The actual pattern produced by the jet was plotted by attaching surveyor's ribbon in a grid pattern on the bottom of a sheet of Plexiglas. The Plexiglas was then placed over a full-size spa, and the motion of the ribbons was observed. The triangular pattern of the motion was drawn with a marker on the top of the Plexiglas. By measuring the base and height of the triangle on the Plexiglas, students found the diameter and height of the cone. A development of the cone was made to the same scale as that of

the spa. Several models of the cone were made and placed in the spa to determine the optimal placement of the jets.

Comparison of Solar Heating Systems
The effects of differents types of solar heating systems can be demonstrated easily. Each model was 6" x 6" x 6" with a gable roof. A small hole was made to allow for a thermometer to be placed in the same location on each model. The basic construction material was balsa, with additional components as listed in the description of the models.

Models
1. Contro—No windows or doors
2. Window only—Install a Plexiglas window in a side wall
3. Window with a solar mass—Same as #2 with a plaster of paris wall
4. Window with a solar mass and ceiling fan—Same as #2 with a small battery-operated fan installed in the ceiling
5. Skylight—Install a Plexiglas skylight
6. Skylight with a solar mass—same as #5 with a plaster of paris wall

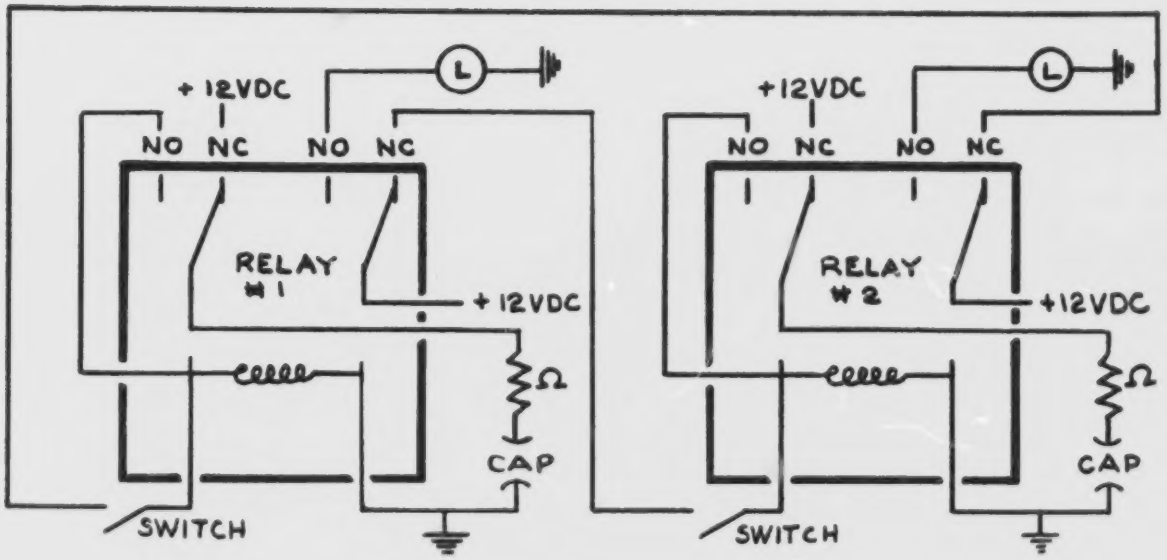
The homes were placed in an unshaded area with the ridge of the model perpendicular to the path of the sun and the skylights and windows positioned to receive the afternoon sun. The inside and outside temperatures were recorded hourly. The data was graphed and analyzed for patterns. The experiment was repeated on both sunny, partly cloudy, and cloudy days.

Remote-Control Firefighting Robot
The hazardous duties of firefighters brought about this idea. A prototype of a firefighting robot was produced by using remote control technology. A small remote-control dune buggy was modified with a platform. Mounted on this platform was a small water cannon (available through electronics warehouses), a water reservoir, and an RC airplane servo. The directional control of the water stream was accomplished by using the servo, combined with the steering of the vehicle, to elevate the exit tube of the water cannon. With these components, the robot was used to put out a small fire. Although the robot requires two operators, the principle of robotic firefighting is exhibited.

Winner Signal for Scale Racetracks
This project was designed to determine the winner of a drag race between two scale model cars. The cars raced side by side along a track. Research was done on the capabilities of commercially available winner signals. The following requirements were used for design considerations:

1. The system would be a mechanical type switching system to keep cost down.
2. The winner would be designated by a light. The system would then reset itself after a short period of time.
3. The mechanical switches would be recessed into the track. They would be triggered by the race cars running over a wire arm.
4. The system would have its own power source.

A schematic of the circuit is included. The components were acquired from a local electronics supply house. The components are easily altered to adapt to other types of tracks. As the first momentary switch is depressed, it activates a relay and two things occur. First, a capacitor discharges, and the light on the winner's lane will light. Second, an opening in the loser's light circuit is created and will not allow the light to activate. After the capacitor completely discharges, the system will reset itself for the next race.


+12VDC
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SWITCH

RESEARCH NOTEBOOK

Essential Elements: Common: 4, 5
Specific: 6, 11
TAAS Objectives: Language Arts: WC 1-7

Summary
The purpose of this notebook is to allow the students to document the steps taken in their research project. Records will be kept in several forms, including written and visual.

Equipment/Supplies
1. 3" binder
2. Looseleaf dividers
3. Photo album sleeves
4. 35mm slide cover (3-ring binder)
5. 35mm negative sleeve (3-ring binder)
6. VHS videotape
7. Periodic goal sheet
8. Project goal sheet
9. Budget form
10. Calendar
11. Daily log

Notebook Sections
Goal Sheet (see sample)
This section allows a student to establish an overall goal for the research project. The goal statement should be very specific as to the expected outcome. In addition to the overall goal, the areas of expertise needed to achieve this goal are listed. These should include any areas in which the student must develop skills in order to complete the project. These areas include things such as gears, motors, soldering, plastics, etc. Completing this form will help the student to determine the resources needed to complete the project.

Periodic Goal Sheet (see sample)
Periodic evaluation of the progress on a research project is necessary to keep the student on task and to facilitate grading. The completion of this form will help keep the short-range goal in sight. In addition to giving direction to the student, it will help the student to set appropriate goals for a given situation. The student should be given a date for the periodic goal sheet to be completed (submission date). Also, a date for the evaluation of the goals must be set. This time frame for evaluation can be adapted for different students. Those students with more self-discipline may be evaluated less often, and vice versa. Upon submission, the goals for that evaluation period should be reviewed and approved. The goals set at the beginning of the year are very likely to be too broad and unachievable for the time allotted. Direction should be given, but do not set the goals for the students. Allow the students to realize that their goals are not appropriate.

Basic (Investigatory) Research
All research projects will begin with some sort of basic research. This may be as simple as going to the library to read what has been published on a topic. Using the Project Goal sheet in conjunction with basic research will refine the actual topic of research. In some cases, the answer

to the original idea may be given in the basic research. This will allow the student to adjust the topic to include some type of applied research.

Research Outline
After the basic research has been done and the project goal has been established, it is time to decide on a plan of attack. The research outline is a method of planning an order of events. The original form of the outline will be quite broad. As each section of the outline is approached, the first step will be to add detail. In a sense, the original form is just a list of the areas the student must complete in order to complete the project. As time progresses, each area will be researched further and detail added to help complete that step in the process. These smaller areas may be used as periodic goals.

Research Notes/Daily Log
Documentation of research is extremely important. Students should be required to record the events associated with their research in some manner. Data from experiments is only one area of documentation. Students see that charts, graphs, and data records are important. These will be required to draw conclusions. Just as important as the actual data is the reasoning behind certain decisions. When compiling the technical paper at the end of a research project, justification for the methods used, the decisions made, etc. are important in explaining results. A daily log is an easy way of keeping this type of information. The length of entries into the log will vary with different events. They may consist of only a description such as "soldered components on pc board." More importantly, they could include the reasoning for some decision such as "because of the inefficiency of the wind generator we changed our auxiliary power to a solar panel." These entries will assist in the reporting of results.

Calendar
A calendar must be included for the student to record important dates and events. Dates such as periodic evaluation dates, holidays, end of grading period, exams, exhibitions, etc., should be included.

Budget/Materials
The results of each project must be evaluated in terms of the money spent. The students should record the materials and cost of all supplies used during the research. If an exact cost cannot be determined, then record an estimated cost.

Technical Paper/Video Presentation
The results of all research should be reported. The technical paper will show the students the necessary steps in reporting results in a written form. In addition to text, charts and graphs must be prepared to illustrate these results. The videotape presentation will give the student a chance to show the results in an alternative and summarized form. A question and answer session at the end of the presentation will inform the student of the effectiveness of the presentation.

Research Documentation
In addition to written documentation, other types of documentation may be appropriate. Videotape is an excellent method to use for later review of events for evaluation. This will also show problems or biases encountered during research. Photographs are also appropriate and sometimes more easily available. Photo sleeves, 35mm negative sleeves, 35mm slide sleeves, and videotape storage should be provided in some form.

Table of Contents
This table of contents can be arranged in any order. The order shown on the following page allowed easy access to the parts of the notebook used most often.

Suggested Table of Contents

I. Calendar
II. Project goal sheet
III. Research outline
IV. Basic (Investigatory) research
V. Research notes/daily log
VI. Budget/materials
VII. Periodic goal sheets
VIII. Technical paper
IX. Research documentation
    A. photo sleeves
    B. 35mm negatives
    C. 35mm slides
    D. videotape

Project Goal

Research & Development

Student: _____

Project Title: _____

_____

Overall Goal: _____

_____

_____

_____

_____

Major Areas of Research: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Approval: _____ **Date:** _____

Periodic Goal

Research & Development

Student: _____

Project Title: _____

_____

_____

Submission Date: _____ **Evaluation Date:** _____

Approval: _____

Expectations	Evaluation
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
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_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

DOCUMENTARY PROJECT

Essential Elements: Common: 1, 2, 4, 7, 9A, 10
Specific: 1, 2, 4-9
TAAS Objectives: Language Arts: RC 2, 4, 5, 6

Activity Summary

This activity is designed to be an end-of-the-year project for the entire class. The class selects a topic or subject matter and then, using whatever materials or processes each student wishes, the class assembles a multimedia program. This allows each student to study a new area of research or to apply one which they explored in an earlier assignment.

Teaching Tips

1. This project is designed to involve the entire class on one thing while still allowing each student to explore his/her own area of interest: black-and-white or color photography; 35mm, 120mm, or large format equipment; video; slide shows; computer graphics; etc.
2. The end result should be some type of exhibit, designed by the students, that can be shown at the school or somewhere in the community.
3. The teacher should act as the coordinator of the project, but the students should be involved in the assembly of the total project, including selecting the work to be shown. Have students submit their research to the class and then the work is juried by the entire class.

Instructional Strategy

- Allow the students to brainstorm for a topic that they are all interested in. Once the topic has been selected, each student is responsible for defining how his/her research project can work to support the overall project. It is up to the instructor to determine whether the approval for the project should come from the class or from the instructor. Possible topics might include businesses (or business people) in the community, a part of the community that people are not aware of, something about the school or school district, etc. The topic should be broad enough for the entire class to work with, yet at the same time not so broad that there is no central theme.
- Weekly deadlines should be established for the students to examine each other's work. This allows the students to critique each other as well as offer advice on directions for the student to take his/her work. This will also help the students meet the final deadline.
- As part of the project, the students (with the instructor's help) should locate some place to exhibit the final project. This might be somewhere in the school, at the school district administration building, or somewhere in the community (library, city hall, other).
- Some students might even channel their research into finding financial support for the documentary, finding exhibition space, preparing invitations to an opening (graphic arts processes), or handling other organizational duties.

Equipment/Supplies

Will depend on the individual processes that the students select. This might involve black-and-white processes, a slide-tape program, video, color printing, desktop publishing, etc.

Evaluation Key

It is important the students feel that this documentary is "their" documentary. Part of the grade that each student receives should be based on an evaluation of the individual research projects by the other students in the class. This evaluation should include a discussion of the contribution of the individual's research to the total project.

The instructor should also grade each student's work, basing the grade on the work and the student's written discussion of the basic and applied research that she/he was involved in as part of the overall project.

DOCUMENTARY PROJECT

A multimedia project for the entire class

Objectives

- To produce a series of individual research projects that combine to create one exhibition dealing with a central subject or theme
- To explore the school or the community in depth; to build a document of something that the students in the class feel is important
- To work together as a group to create a display that encompasses a wide range of visual communication processes

Vocabulary/Concepts Reinforced

- Basic and applied research
- Visual communication
- Problem-solving skills
- Group skills

Equipment/Supplies

Will depend on the individual processes that the students select. This might involve black-and-white processes, a slide-tape program, video, color printing, desktop publishing, etc.

Introduction/Procedure

A document is defined as "anything relied upon to record or prove something." This research module provides the student, and the entire class, with the opportunity to build a document about a selected subject, using photographs, printed matter, or other form of visual media.

This exercise should begin with the class deciding upon a single topic around which to build the document. This topic could concern something at the school or in the community. Possibilities might include: a series profiling businesses or business owners in town; an in-depth look at how the students at the school contribute to the community; something that requires action by the community or the school (the homeless, pollution, traffic); a profile of specific classes offered by the school or district; or some other idea which the entire class can agree upon.

Once a general topic has been selected, it is the responsibility of each student in the class to define his or her part of the overall project. Each individual research topic should tie into and support the document. If, for example, the class had decided to produce a profile of businesses in the community, one student might choose to photograph in black and white a series of environmental portraits of some of the business owners. Another student might decide to prepare a video showing the businesses at work. And still another student might select large-format color prints to show the physical facilities of some of the businesses. The important part is that each student's research should support the theme in some manner.

As part of the basic research, the student should find examples of professional work similar to what the she/he plans to produce. This work should be examined and evaluated to help plan the applied research the student intends to do.

Weekly deadlines should be established by the class, with the aid of the instructor, so that students can look at each other's work and help suggest ways to improve or

strengthen it. For the final deadline each student should prepare his/her research project so that the rest of the class can evaluate it and determine its support of the entire document.

Once all the work is selected for the exhibit, the students should hold some type of opening, inviting the community to see the results of their labors.

Support Materials

The work of the following artists might be viewed:

- Mary Ellen Mark—photographs and film (*Streetwise*)
- Farm Security Administration photographers during the Great Depression: Dorothea Lange, Walker Evans, Ben Shahn, Russell Lee, etc.
- Arnold Newman—environmental portraits
- Eugene Atget—documentary photographs of Paris
- William Albert Allard—documentary photographs
- Geoff Winningham—*Rites of Fall*, Austin: University of Texas Press, 1979.
- Garry Winogrand—*Stock Photographs*, Austin: University of Texas Press, 1980.
- *National Geographic*
- Current annual reports

JOURNAL/SKETCHBOOK

Essential Elements: Common: 2B, 4B, 4D, 10
Specific: 2
TAAS Objectives: Language Arts: RC 4-6
WC 1-6

Activity Summary

This activity requires the student to keep both a weekly diary to practice writing skills and a sketchbook of photographs that can be used to generate ideas for future research topics. It also assists the student in learning to evaluate photographs.

Teaching Tips

1. This assignment can be ongoing throughout the school year. Every other week students turn in a journal containing two weeks' worth of entries and two critiques. The journal is designed to be both a diary for the student as well as an idea book for future photographic assignments.
2. The purpose of the diary is to have the students work on learning to express themselves verbally. The verbal part comes through a daily or weekly record of their activities. This diary is not read by the instructor, but is just checked to see that the students are doing it. Students should fold the page over if they do not want the teacher to read their entries, and the instructor should respect their privacy.
3. The diary is given a check grade to show that the students are working on it.
4. In addition to the diary, the students select photographs that they like or admire. These photographs are photocopied and placed in the journal, along with a written critique of the work. These photographs should be from books or magazines, not personal work. These "looking reports" can receive some type of grade from the instructor.
5. Besides evaluating the photographs, the students must also sketch or describe how they would photograph the same subject differently, not to necessarily make it a better shot, but to make it their own.
6. This section of the activity is designed to work on visual communication skills and problem-solving skills.

Instructional Strategy

- Lecture to present the topic to the students. Encourage them to feel free to express themselves in the diary portion, but let them know that the instructor will read the critique section.
- Occasionally the instructor might bring some image into the class and have the entire class write individual critiques of the image and then discuss their comments.

Equipment/Supplies

1. Books/magazines/other sources for photographs
2. Students supply notebook

Evaluation Key

Evaluation of the diary is based solely on whether or not they complete the assignment. Evaluation of the critique should be based on whether or not they have discussed the questions fully and offered their own idea(s) on new ways to photograph the same type of shot.

JOURNAL/SKETCHBOOK

Practice skills in both verbal and visual communication.

Objectives
- To keep a daily/weekly journal of the student's activities
- To practice evaluating photographs in terms of composition, lighting, and message
- To generate ideas for future photographic assignments

Vocabulary/Concepts Reinforced
- Writing skills
- Problem-solving skills
- Lighting
- Composition

Equipment/Supplies
- Books/magazines/other sources for photographs
- Notebook or sketchbook

Introduction/Procedure

The Journal/Sketchbook has two purposes. One purpose of the journal is for you to have a place to put down your thoughts and feelings as you go through the everyday processes in the life of a high school student. You should work on learning to express yourself, both in your writing in the journal and in your photographs for the class. You need to understand that it is important to be able to put what you are thinking or feeling into words. This will be an opportunity for you to do that without having to worry about anyone else reading it. All the instructor will do is check to see that you are working on it. The instructor will not read what you have written unless you desire it. Sometimes, a specific topic or image will be provided for you to write about. But there are two other parts of your journal that the instructor will look at. On a weekly basis, you should select one photograph that you like out of magazines, books, or whatever other sources you might find. This photograph should be photocopied and put it into the journal. Along with this photograph, you are expected to write a critique of it. Discussion should include—

The lighting used:
- Is it artificial or natural? How can you tell?
- How many lights were used if it is artificial?
- What direction(s) is the light coming from?
- What is the quality of the light?

The composition of the photograph:
- What is the main subject?
- Did the photographer use any design elements or principles? Which ones?
- Is the composition simple or cluttered?
- How did the photographer place emphasis on the subject?

The technical quality of the image:

- Does the technical quality help or hinder the image?

What is the photographer trying to communicate in the photograph?

- Is he/she trying to persuade the viewer? sell the viewer? anger the viewer?
- What is the purpose of the photograph?
- Is the message communicated effectively?

Why did you select this photograph?

- What is it about this image that attracted you?
- What emotional or physical impact does the image have on you?
- Is there something here that you would like in your own work?
- Is it the process, subject matter, camera angle?

Are there any flaws in the image? Are there any other comments you would care to make about the work?

- In addition, you should sketch or describe how you would photograph the same subject *differently*. It is not an issue of making the photograph "better," but of making it your *own* image.
- You will receive a grade for this part of the journal. The personal writings will receive a check-grade if they are completed.
- The journal should also be used to keep track of ideas for photographs that you would like to do. Use the journal as a brainstorming tool to think about what areas of photography you are interested in pursuing or exploring further.
- While the teacher will not grade you on your grammar and punctuation, he/she is looking at your content, reasoning skills, and your discussion of the questions raised above. It should be stressed that good communication requires both the choice of appropriate words and their correct usage. You should strive to do your best.

RESEARCH FUNDING FOUNDATION

Essential Elements: Common: 1, 3, 4
Specific: 1, 10
TAAS Objectives: Language Arts: WC 1-6

Activity Summary
The students will participate in the formation of a foundation to distribute research funds and apply for these funds.

Teaching Tips
1. Discuss the need for research funding before beginning the activity.
2. Use the R&D Project Notebook in conjunction with the activity.
3. Use the checklists provided.
4. If funds are not available through your budget, have a fund-raiser or solicit funds from individuals or businesses.

Instructional Strategy
- Act only as a resource person/guide during process. Allow students to create as much of the foundation as possible.
- Emphasize professionalism.

Equipment/Supplies
1. Reproduce handouts/sample forms as needed.
2. Video camera/television

Evaluation Key
1. Participation
2. Student/teacher evaluation of presentations
3. Funding results

RESEARCH FUNDING FOUNDATION

Form a foundation for the funding of research grants.

Objectives

- To participate in the process for acquiring funding for a research project
- To participate in the formation of an organization for the distribution of research funding
- To establish criteria for the evaluation of research ideas
- To evaluate research proposals

Equipment/Supplies

- Video camera/television

Introduction

The ability to do effective research is limited by the money available. The acquisition of funds is a process that becomes very involved with rules, regulations, guidelines, and competition. Although an idea may have merit to the individual involved in the research, the persons involved in the allocation of funding must be sold on the idea. Your job will be to participate in the formation of a foundation whose job it is to allocate money to interested parties involved in some type of research. You will have to establish criteria, evaluate prospective ideas, establish funding amounts, and critique results of different research projects.

Procedure

Organization of a Foundation

The foundation which you establish will include all the individuals in the research class. When a foundation is formed, its main purpose is to satisfy a need. The first step is to establish the purpose of the foundation. This is a brief written statement describing the function of the foundation.

Any organization must have an established set of leaders. In this organization, your teacher will be the Chief Executive Officer, and the students will make up the Board of Directors. The Board must decide the officers needed for the smooth operation of the foundation. A chairperson will need to be elected to preside over meetings. Elections should also be held to fill any other offices decided upon by the Board.

The last step in the organization is deciding on a name for your foundation. You should consider a name that will reflect the purposes and desires you wish to see in the research that you fund.

Business Procedures

Once the organization is complete, it is time to begin establishing the business procedures needed to complete the goals of your foundation. Since the purpose of your organization is to allocate funding, the first step is to determine the source and amount of funds available. Your teacher should help with this information.

A new organization must inform the public of its existence and purpose. A plan must be established for the advertisement of your foundation and also solicitation of prospective researchers. This can be done through several different media. List the publications, television shows, etc., that would be appropriate for your advertisements. Next, design ads, commercials, letters, etc., that will be placed in the different media.

Once an advertising campaign has been established, you must establish the step-by-step procedure for persons requesting funding to follow. The first step is to design an application form. This should be filled out and returned by the applicant with a letter of introduction that includes a brief description of the research project and the amount of funding needed. The foundation will design a form letter acknowledging receipt of the application and designating the date and time for the presentation of the applicant's request.

One of the most critical areas will be the evaluation of each presentation. In order to assure a fair evaluation, the criteria that will be used to evaluate the presentations must be decided upon. Several possible areas of evaluation are the merit of the research idea, the quantity of funding requested, the quality of presentation, and the enthusiasm toward the project. Decide upon these and make a list of the items that you feel are important. These criteria are placed on an evaluation form to be filled out at the presentations (see sample evaluation form). Design a form which will allow you to record your responses to the criteria, make remarks, and give an overall rating to the presentation.

During the actual presentations, the Board of Directors will fill out the evaluation forms and videotape each presentation. Once all presentations have been made, the analysis of the evaluation forms will establish who will receive money and how much funding each applicant will receive. There are several ways in which to establish funding levels. A summary of the evaluations will initially rank the presentations. Using this as a starting point, you can give a rating to each project such as "A, B, C, D" or "1, 2, 3, 4." Establish the number of different levels needed and give them a name. Once the leveling has been completed, the allocation of money must be attached to each level. There are several ways to allocate money to each level. One example is to fund each level with a set amount of money. Another is to give a percentage of the amount of funding requested according to the different levels. Decide how the money will be allocated, and record the funding levels and amounts for each applicant. A form letter with the results of your evaluation and a description of how the money will be distributed must be sent to each applicant (see sample letters).

When distributing money, take care to also evaluate the progress of the project. A lump sum payment at the beginning of the project is not a good idea. A periodic inspection into the progress of the project can be required before additional money can be distributed. The last procedure is to establish a timeline for reporting back to the foundation with a presentation describing the progress toward the goals of each project.

Upon completion of a project, each applicant should be required to disclose the results of the research through a written paper and a presentation to the board of directors.

Operating Procedure

Now that you have made the decisions as to how the foundation will be run, it is time to put them into practice. Using the checklist provided by your teacher, the Chairperson of the Board should make sure that all necessary forms, letters, etc., are complete. Applications and letters of introduction must be completed and returned to the foundation. The form letter with the date of the presentations must be sent to the applicants. Next, students should prepare their research proposals. On the day that proposals are presented, a video camera should be used to tape the presentations. Each student will be introduced to the Board of Directors and allowed time to present her/his proposal and answer questions. After the presentation, the Board will fill out the evaluation forms. Also, each applicant will watch the videotape and evaluate his/her presentation.

Upon completion of all presentations, funding levels and money allocations must be assigned and the form letter with those results sent to each applicant. It is now time to begin your research. Remember to document your research for your progress reports to the Board of Directors. Good luck!

Foundation for Innovation and Technology

5150 DeZavala Rd.
San Antonio, TX 78200
(512) 555-1234

October 20, 199_

Student
Clark High School
San Antonio, TX 78200

Dear Colleague,

We would like to thank you for your interest in the progress of technology and also congratulate you on your receipt of funding for your research project. Your presentation has convinced us to include you in our current cycle of funding. Each project accepted for funding is assigned a funding level. These levels establish the initial amount of funding awarded and also form the priority by which additional funds will be allotted. Your current funding level is shown on the attached list of all projects funded during this cycle. Additional information on the guidelines for management of these funds will follow. Again, we wish you hearty congratulations for your efforts and the best of luck in your research endeavors.

Sincerely,

Teacher
Chief Executive Officer
Foundation for Innovation and Technology

Foundation for Innovation and Technology

5150 DeZavala Rd.
San Antonio, TX 78200
(512) 555-1234

October 20, 199_

To Whom It May Concern:

Listed below are the recipients of funding by our foundation for the current cycle. Included are the initial funding level, initial amount of funding, and priority for the distribution of additional funds.

NAME	FUNDING LEVEL	INITIAL FUNDING	FUNDING PRIORITY
Alan Alford	"D"	$10.00	9
Jennifer Buckner/ Bill Sherwood	"B"	$20.00	5
Chad Degrasse/ Ben Williams	"A"	$25.00	1
Steve Delarosa	"C "	$15.00	6
Steve Granger	"A"	$25.00	3
Andy Lin	"B"	$20.00	4
Kyle Lovejoy	"A"	$25.00	2
John Stuart	"NF"		10
Jason Van Eaton	"C"	$15.00	7
James Washington	"D"	$10.00	8

Foundation for Innovation and Technology

5150 DeZavala Rd.
San Antonio, TX 78200
(512) 555-1234

October 20, 199_

Student
Clark High School
San Antonio, TX 78200

Dear Sir/Madam:

We regret to inform you that your request for funding of your research project has been rejected. The presentation of the project was not up to the standards that we feel are necessary in order to grant funding. However, we would like to offer you another opportunity to apply for the funding needed for your research. If you wish to use this opportunity, please contact us in writing for an appointment. Your letter must be received in this office by Friday, October 27, 199_, and we will expect to see your presentation on Monday, October 30, 199_. We hope that you will be better prepared at this time, as it is our intention to fund as many research projects as possible, so far as they uphold the high standards of professionalism associated with our foundation.

Sincerely,

Teacher
Chief Executive Officer
Foundation for Innovation and Technology

FOUNDATION CHECKLIST

Complete	*Topic*
	I. Organization
_____	A. Written statement of purpose
	B. Officers
_____	1. Chief Executive Officer (teacher)
_____	2. Board of Directors (students)
_____	3. Chairman of the Board
_____	4. Other officers (as needed)
	C. Foundation name _____
	II. Business procedures
	A. Funds
_____	1. Source(s) _____
_____	2. Amount _____
	B. Advertisement
_____	1. List of publications/television shows/etc.
_____	2. Ad design
	C. Application procedure
_____	1. Application
_____	2. Letter of application receipt and presentation date
_____	3. Evaluation criteria
_____	4. Evaluation form (see sample)
	D. Evaluation procedure
_____	1. Funding levels and money allocation
_____	2. Funding notification letters (see samples)
_____	3. Funding distribution procedure
_____	4. Progress timeline

INDIVIDUAL STUDENT CHECKLIST

Name: _____

Complete	*Topic*
_____	1. Application
_____	2. Letter of introduction
_____	3. Received confirmation/presentation date letter
_____	4. Fill out presentation evaluations on all students
_____	5. Presentation
_____	6. Self-evaluation (have student watch videotape)
_____	7. Received letter of presentation results
_____	8. Periodic progress reports to board
_____	9. Research paper
_____	10. Research presentation

Foundation for Innovation and Technology

Presentation Evaluation

Presenter: _____

Project Topic: _____

Rating Scale:

1—Poor 2—Below Average 3—Average 4—Above Average 5—Superior

Presenter **Overall Rating** _____

1.	Organization	1	2	3	4	5
2.	Preparation	1	2	3	4	5
3.	Enthusiasm	1	2	3	4	5
4.	Speaking Effectiveness	1	2	3	4	5
5.	Professionalism	1	2	3	4	5

Presentation **Overall Rating** _____

1.	Visual Aids	1	2	3	4	5
2.	Organization	1	2	3	4	5
3.	Effectiveness	1	2	3	4	5

Project **Overall Rating** _____

1. Merit 1 2 3 4 5

2. Feasibility 1 2 3 4 5

3. Commercial Value 1 2 3 4 5

4. Cost Low Moderate High

5. Possible Benefits

General Comments: _____

Evaluator: _____ **Project Rating** _____

FIELD NOTEBOOK

Essential Elements: Common: 5-10
Specific: 4, 7, 9, 11
TAAS Objectives: Language Arts: RC 1-4
WC 1-7

Activity Summary

This activity is intended for use by advanced-level research and development students involved in any of the major instructional areas. Students will use this activity to follow and record the various stages of development, fabrication, or manufacture of a specific product. The activity will be described as following a general construction project; however, it can easily be adapted to meet your own instructional needs. Students will monitor the various stages of a process, photograph these stages, write a general description of each stage, and present their completed project to the entire class for discussion.

Teaching Tips

1. Read through the activity and become familiar with the various stages of the project.
2. Provide for periodic progress checks during the course of this activity.
3. Help students select a topic for their project. Suggested activities might include building a house, building a bridge, producing a television commercial, using a computer CAD system, etc.
4. Contact several potential sources for your students to use.

Instructional Strategy

- Use this activity as an individual long-term project.
- Use this activity in conjunction with a written technical paper if necessary.

Equipment/Supplies

1. 35mm camera with color slide film
2. 3-ring binder with plastic sleeves for holding mounted color slides
3. Personal computer with word processing software, if available
4. Slide projector
5. Miscellaneous pens, paper, etc.

Evaluation Key

1. Teacher evaluation should be based on participation in and completion of the activity.
2. Establish specific criteria, such as topic, number of slides required, amount of technical data, etc., that you expect your students to provide before you release the activity to them.
3. The completed product should be such that it can be presented to other students for class discussion.

FIELD NOTEBOOK

Complete a field notebook to track and record the various stages of an industrial process or procedure.

Objectives

- To describe and discuss the various stages of development used in a designated technical process

Vocabulary/Concepts Reinforced

- Developmental stage—The manufacture of a product generally depends on a well-planned sequence. Each step or stage in the process determines the quality of the finished product.
- Sequence of events—Most manufactured products also depend heavily on a specific sequence of events. Each stage in the process generally must be performed in a carefully controlled sequence.

Equipment/Supplies

- 35mm camera with color slide film
- Binder with plastic sleeves for holding color slides
- Notebook paper for keeping field notes
- Personal computer with word processing program for preparing technical information

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Introduction

This activity is intended for use by research and development students to track the stages or sequence of events used in the production of a product. Students will select an approved industrial process or procedure and photograph the various stages of its development. Additionally, students will keep a written record to describe what is happening at each stage. These slides and notes will be used as a presentation to the other students in the class.

Procedure

1. Begin by selecting a topic approved by your instructor.
2. Contact the necessary supervisor who can authorize you to monitor and photograph the sequence of events. Note that some companies have strict guidelines about visitors and observers which might restrict your observations. You will need to respect these particular regulations.
3. Prepare an outline to follow. You will need to consider the various stages and the sequence of events that you will want to include in your project.
4. As the sequence of events begins to unfold, you will need to photograph and take notes about what is actually taking place. Remember that you will present your field notebook to the class upon completion of the project, and you should be prepared to present as much information as necessary to cover the topic.
5. The stages of development that you track should reflect the actual sequence of events as closely as possible. If, for instance, you are tracking the construction of a house, you need to record each step from staking out the foundation, through rough construction, to interior finish work. This project may take several months to complete depending on the topic you have chosen.

6. When the sequence of slides has been completed, edit your field notes to serve as a script to accompany the slides. Number each slide in the sequence and prepare the script so that it could be read by anyone presenting the slides.
7. When your field notebook is ready for presentation, your instructor will ask you to share it with the class. Your instructor will encourage a class discussion of the presentation.
8. Upon completion of the presentation, submit your field notebook containing slides and notes in a binder for your instructor to evaluate.

BASIC PRINCIPLES OF RESEARCH

Essential Elements: Common: 10
Specific: 1-4, 6-11

TAAS Objectives: Language Arts: RC 1-6
WC 1-7

Activity Summary

This activity is intended to introduce students to the basic principles of research and development. Students will select an area of interest from one of the major areas of technology such as communication, production, or energy, and complete a technical paper on how research and development is accomplished in that particular area.

Teaching Tips

1. The instructor should become familiar with the activity before releasing to students.
2. Encourage students to complete this activity before initiating any individual or group activity.
3. Stress the importance of research and development techniques used by industry as well as the technologies associated with your particular instructional area.
4. Provide access to research material for your students by setting up a reference area within your lab.
5. Consult with your school librarian about providing any necessary help that your students might need in using the school library. The librarian might want to meet with your students to discuss the various reference materials that are available on campus.
6. Review the Technology Systems Model and become familiar with the concepts of resources, processes, impacts, and applications. This model and its supporting concepts will be the basis of study and instruction for many of the learning activities contained in this guide.

Instructional Strategy

- Use small group or individual discussions to introduce the activity.
- Use the activity as either an individual or small group problem-solving project.

Equipment/Supplies

1. Personal computer with word processing program if available
2. Individual computer disks
3. Computer printer with paper
4. Three-ring binder for storing collected data

Evaluation Key

Evaluation should be based on pre-established criteria which you identify before students begin their project. These include length of time, number of pages, format to use (see technical paper activity), topic area, and any additional criteria which you feel need to be addressed by your particular students.

BASIC PRINCIPLES OF RESEARCH

Learn about principles of basic and applied research.

Objectives
- To describe the two major types of research
- To discuss the importance of research in the context of developing new technologies
- To be able to initiate an applied research project

Vocabulary/Concepts Reinforced
- Research and development—The process of developing new technologies or products through a systematic process of problem solving.
- Basic research—Research where basic knowledge is sought in a broad based area, such as alternate energy sources, rather than a specific area, such as wind-generated electrical power.
- Applied research—Research where a specific problem is addressed, such as the development of wind-generated electrical power.

Equipment/Supplies
- Personal computer with word processing program, if available
- Printer with paper
- Floppy disks for storing student research data
- 3-ring binder for storage of printed data
- Additional materials as needed

Introduction

One of the most important functions of modern science and industry is the development of new and improved technology. The process known as research and development is responsible for discovering and developing this new technology. Virtually all areas of modern industry, including engineering, manufacturing, education, medicine, and agriculture, are dependent upon individuals to research and develop new and improved ways of doing things. Research and development processes rely on a systematic approach to make these discoveries. Researchers use highly organized scientific investigation methods to insure meaningful results.

Advanced-level students involved in a variety of Industrial Technology areas should become aware of the research and development processes and techniques used in their particular area of interest. This activity will help students develop a better understanding of the overall workings of that particular technology.

Background Information

We are constantly affected by the results of research and development. Many of the things that we use on a daily basis, such as the color television, personal computers, digital clocks, microwave ovens, etc., are the direct result of research and development. Even the medicines we take and the processes used in surgical procedures are direct results of research and development in the medical field. The food that we eat is another result of research and development in the area of agriculture as it strives to produce new and improved methods of growing crops and raising livestock.

There are two distinct approaches to research and development. The first has to do with learning more about unknown areas. This type of research, known as **basic research**, is generally broad-based, with no single result targeted for discovery or development. Basic research is not geared toward any specific end but attempts to learn more about a broad concept. A good example of basic research would be in the area of alternate energy sources. In this case the researcher does not have a specific end result in mind but seeks to discover new basic knowledge which might deserve further research in its own right. Because basic research does not have specific results in mind at the outset, results are most often unpredictable.

The second type of research is known as **applied research**. In applied research the researcher begins with a specific goal in mind. Using the knowledge gained from basic research in, for example, alternate forms of energy, the person interested in applied research might wish to select a specific end result such as the application of solar energy to provide electrical power to isolated agricultural irrigation pumps. In this case, the researcher knows exactly what the problem is, to provide electrical power to an isolated irrigation pump where conventional electrical power is not readily available. He therefore sets out to discover how to use solar energy to generate electrical power for the irrigation pump. If his research is successful, he will likely develop a product which has some practical application to the initial problem.

Many large industrial companies, such as IBM, General Motors, 3M, General Dynamics, as well as major universities across the country, support facilities for researchers to perform both basic and applied research. They realize the importance of the research and development process and budget millions of dollars annually to achieve the best possible results. Consortium research groups, such as the MCC Corporation in Austin, Texas, have been organized by some of the larger microelectronics manufacturers to perform both basic and applied research. Research and development is big business and will continue to work towards new and improved technology to better the lives of all of us.

Research and development is completed through a highly organized set of procedures or stages. The four stages of this process include the following:

1. Statement of problem
2. Collection of background data
3. Analysis of information
4. Development of the solution

As in our example above, the first step is to identify the problem—to provide electrical power to an isolated irrigation pump where no electrical power exists. The statement of the problem may be a very simple statement or it may be a very complex set of parameters.

The second stage in the process is to collect any related data that might help the researcher solve the problem. This may or may not be an easy process depending on what basic research has been completed in the area. In some cases there will have been extensive basic research completed, while in other areas there may not have been any basic research completed at all.

The third step is to analyze the material to determine which information is useful and what is not. Analysis is the process of sorting through the collected data to determine what is relevant to the problem. Careful analysis is a matter of efficient

research. The researcher may want to be able to duplicate a particular process, but she/he certainly does not want to waste time "reinventing the wheel," as the saying goes.

The fourth and final stage in this process is the discovery or development of the solution to the initial problem. It is at this level where the efforts of the research gathering and analysis are put to work. The researcher applies what he has learned to the development of a practical solution. In our example the researcher develops a solar-powered electrical generator with enough capacity to operate an electric motor that will efficiently operate the irrigation pump. The pump is put into service and tested by the researcher to verify that his idea is, in fact, a cost-effective solution to the problem.

In the real world of industry and technology, researchers play a very important role. The United States continues to be the leader in research and development in most areas of technology. The world has grown to expect continued successes from our scientists, doctors, engineers, and educators. The future for research and development is promising, and both the federal government and private industry have a strong commitment to the continued growth of this process.

Procedure

1. Select an area of interest from one of the major Industrial Technology study areas such as communication, energy, or production. Your assignment is to research how one of them does research and development. An example might be the development of energy-efficient materials for building construction, such as windows, doors, siding, and roofing. Your task is to report on how industry develops these products through their system of research and development.
2. Answer these basic questions as you begin your research project.
   A. Who are these people?
   B. What do they develop?
   C. When did they develop the technology?
   D. Where do they work?
3. Organize your material into a technical paper that you will present to the class. The length of the paper will be determined by your instructor.

Evaluation

Assessment of student performance should be based on individual teacher criteria. Your instructor will provide the evaluation criteria, such as length of time allotted for the project, number of pages in the technical paper, procedures, topics, etc.

RESEARCH AND DEVELOPMENT PROBLEM-SOLVING MODEL

Essential Elements: Common: 2, 8-10
Specific: 1-11
TAAS Objectives: Language Arts: RC 1-6
Mathmatics: O 1-4
PS 3

Activity Summary

This activity is intended to provide students with a problem-solving model which they can apply to research and development level projects. The activity can be used in conjunction with Activity 1 as a more detailed approach to problem-solving in research and development areas. Students will complete a basic problem-solving exercise using the problem-solving model. They will be able to apply this same technique to any variety of problem-solving activities within the research and development subject areas.

Teaching Tips

1. Read through the activity and become familiar with the problem-solving model process before releasing to students.
2. Develop a set of problem-solving activities that can be used within your instructional area. These can be either individual or small group problems as long as they can be solved using the problem-solving model.
3. Prepare a display bulletin board to help illustrate the problem-solving model.
4. Provide an assortment of reference materials for students to use during this course.

Instructional Strategy

- Use a small group or individual discussion to present the topic to students.
- Use the activity as either a small group or individual problem-solving project.
- Become familiar with the Systems Model as a method for problem solving. It is good organizational method for approaching problem solving tasks. Many of the problem-solving activities found in current instructional material are based on the systems model.
- Also become familiar with the Technology Systems Model as a method for instructional planning. Basically, the Technology Systems Model is a method of applying the four principal levels of technology, **resources, processes, impacts,** and **applications,** to instruction. By using these various levels as instructional topics you will be able to better organize and plan activities.

Equipment/Supplies

1. Personal computer with word processing program and printer, if available
2. Any equipment and materials as needed to complete the activity

Evaluation Key

Teacher evaluation of this activity should be based on preestablished teacher criteria for the individual student. The resulting student project may be a written paper, or it might very well be an object, a photograph, or drawing depending on the instructional area involved.

Support Materials

1. Hacker, Michael, and R.A. Barden. *Technology in Your World.* Albany, N.Y.: Delmar Publishers, Inc., 1987.

RESEARCH AND DEVELOPMENT PROBLEM-SOLVING MODEL

Learn about a problem-solving model which can be applied to research and development projects.

Objectives

- To apply the problem-solving model to advanced individual research projects and other special problems
- To describe and discuss the importance of the problem-solving system and its application to everyday situations.

Vocabulary/Concepts Reinforced

- Brainstorming—The process of generating solutions to problems where the goal is to think of as many ideas as possible.
- Trial and error—A method of problem solving where the researcher tries several possible solutions in search of one that works best.
- Experience—A method of research where the researcher applies what he/she already knows.
- Accidental discovery—The method of problem solving where the researcher unexpectedly discovers a solution to a particular problem.
- Compromise—In many problem-solving situations there may be more than one solution. It may be necessary, therefore, to choose elements from several solutions in the final analysis.
- Specifications—The specifications identify the exact parameters the solution must include. In some cases the specifications identify materials to be used, size limitations, colors, etc.

Equipment/Supplies

- Personal computer with word processing program and printer, if available
- Any other equipment or materials related to the instructional area that will aid in the problem-solving activity

Introduction

As you experienced the basic research and development methods in the previous activity you became aware of the general process for researching a problem and developing a solution for that problem. In this activity you will use what many technologists refer to as the **systems model for problem solving**. Basically, both are approaches to problem solving. The research and development process is the traditional method involving both researching and developing solutions to problems. The systems model stresses development of problem solutions and can be applied to a variety of situations from very simple to those which are more complex.

Background Information

The problem-solving model described in this activity is based on the Universal Systems Model which uses the sequence of input, process, output, and feedback as a method of problem solving. Our model includes the processes needed for most problem-solving activities as listed below.

These include:

1. Define the problem
2. Evaluate the specifications
3. Develop a set of possible solutions
4. Select the best possible solution

5. Utilize the selected solution
6. Observe the results and provide feedback or compare the results to the initial goals.

Study the diagram below to better understand how the system operates.

Diagram of Systems Model

1. **Define the problem.** The first step in the problem-solving system is to define what the problem actually is. In order to attempt any effort to successfully develop a solution, you must first fully understand what the problem actually is. In some cases the problem may be very obvious and easily understood, while in other cases the problem may be obscure and not clearly presented.

   An example illustrating this concept is a typical design problem that involves designing and constructing a container to hold a raw egg and protect the egg from breaking when dropped from a height of 6 feet. The specifications and design criteria state that the container must be made from no more than one 8 ½" x 11" sheet of typing paper and no more than 36" of tape. No additional materials can be used to construct the container. Size, shape, color, etc., are not critical elements of the specifications. In this example the problem is clearly outlined. We know what the container is supposed to do and from what height it must be dropped. Further evaluation of the design criteria is necessary to begin solving the problem.

2. **Evaluate specifications.** The second step in the process is to evaluate the available design criteria or specifications which limit possible solutions to the problem. Some of the basic questions asked at this stage are "How big should it be?", "How fast should it go?", "What materials should be used?", etc.

   Establishing the design criteria is often one of the most important considerations. Often the resulting solution to a particular problem is limited by required specifications. These must be considered before a plan can be implemented to solve the problem. As in the case of our example above, the solution to the problem is limited to one piece of typing paper and 36" of clear plastic tape. We also know that our design should protect the egg from breakage when it is dropped from a height of 6 feet. These design criteria and specifications provide us with the basic limits of our solution. Given this information we can begin the development of possible solutions.

3. **Develop the solution.** The solution to a problem is often easy to find and can be accomplished with little or no effort. On the other hand, solutions to a particular problem can be very complex and involve several possibilities. Given the design specifications and criteria we can begin the process of developing a set of possible solutions.

   In order to solve a problem we often draw from our past experience or the experiences of others to formulate a solution. This may very well be the most efficient method of problem solving. On the other hand, we might need to perform a series of trial and error tests to solve a particular problem. By trying several possible solutions we can often come up with one that works best in solving the problem.

Another possible discovery method is that of insight. This is the process best described as solving a problem through creative thinking. Have you ever had an idea just pop into your head? This is known as insight. It is basically the result of creative thinking about a particular problem and suddenly having a revelation about what a possible solution might be.

Another element of creative thinking is that of brainstorming. Brainstorming is a process involving two or more people putting their creative minds together to try to solve a problem. Each member of the group contributes ideas toward the solution of a particular problem. Brainstorming involves critical thinking mixed with individual experiences and a great deal of insight.

Another method of reaching the solution to a problem is through pure accidental discovery. Scientists and researchers often come across important discoveries through this process although their intentions may have been in a totally different direction. Accidental discovery is acceptable as long as it is not the primary method of problem solving.

In the case of our example problem, we might start with a dozen eggs and a stack of typing paper. We would probably have to make several attempts before we came up with at least one method for protecting the egg. The process of "trial and error" is very important to the problem-solving process. There will be some attempts that work, some that almost work, and some that definitely don't work in developing solutions. It is, however, important to try to develop more than one solution to the problem.

4. **Select the best solution**. Once several possibilities have been established, it is time to select the best solution. This is the one which best meets the established criteria and specifications for the problem. In some cases, however, some specified elements may not work in the final solution. Things such as shape, size, color, texture, etc., may have to be compromised in order for the solution to work. These tradeoff components may or may not be acceptable to the final solution, in which case the problem remains unsolved.

5. **Utilize the solution**. Utilizing the solution has to do with putting the solution into effect. In some cases it may involve simply building the object, drawing a design, or writing a technical paper. On a higher level it may very well include developing a mass-production process, alterations to an assembly line, or even building a factory.

6. **Observe the results and provide feedback**. One step that cannot be overlooked in this problem-solving process is to observe and monitor the result of the solution to ensure that it is performing as intended. The monitoring process involves observing the results and comparing them to the initial problem specifications and criteria. This allows the developer to modify the solution as needed. This may be a one-time process, or it may involve selected inspection on an assembly line.

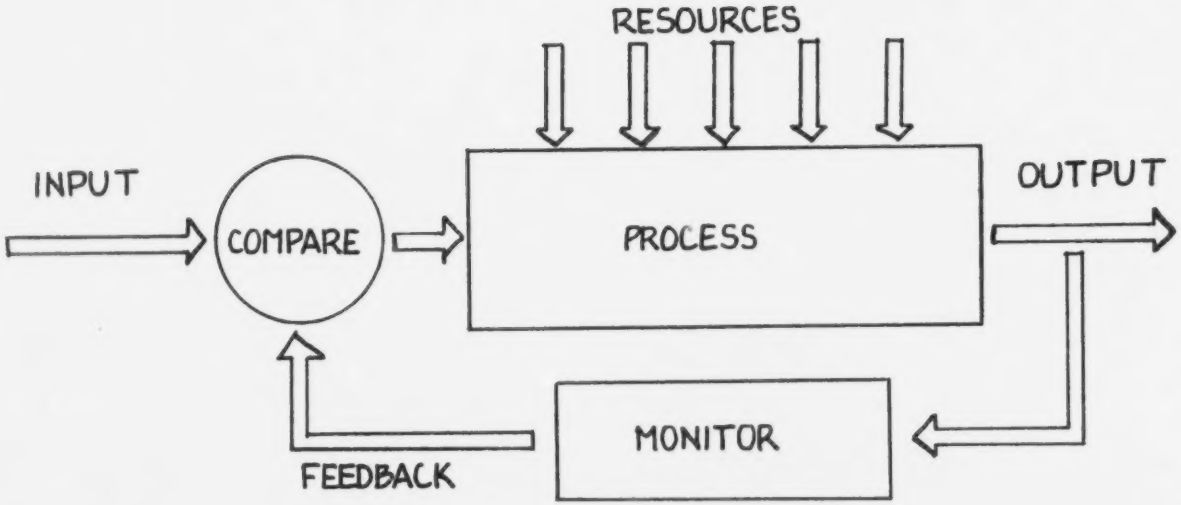
In summary, it is important to note that the model as described above is useful in solving a variety of problems, from basic design and construction to sophisticated fabrication and manufacturing problems. Students involved in advanced-level research and development courses should use these principles when attempting to discover solutions to problems. Students will find that this approach works well in a wide variety of problem-solving situations.

Procedure

1. Complete the basic problem-solving activity assigned by your instructor for the instructional area involved.
2. Write a short technical paper outlining how you used the six basic steps of the problem-solving model to solve your problem.
3. Share your project with other research and development students in the class. In your discussion, talk about how the problem-solving model was used to help solve the problem. Discuss how the model might be used to solve different kinds of problems.

Evaluation

Evaluation of student performance will be based on preestablished instructor criteria.



THE PROBLEM-SOLVING MODEL

BRAINSTORMING

Essential Elements: Common: 1, 10
Specific: 9, 10
TAAS Objectives: Language Arts: RC 1-6

Activity Summary

This activity is intended to provide students with an introductory exercise in brainstorming. The activity is recommended to be used as a one-day experience to introduce the general concept of problem solving in a group setting. This activity will be useful as a method of developing problem-solving skills and creative thinking before beginning the research and development study area.

Teaching Tips

1. Read through the activity and become familiar with the concept before releasing to students.
2. Encourage the use of creative thinking in solving problems by encouraging imaginative responses. Treat unusual responses to this activity with respect; don't discourage individual responses which might inhibit creative thinking.
3. Discuss the importance of brainstorming as a method of group problem solving.
4. Discuss the "pencil" activity described in the student section before dividing the class into groups. Use this as a large group activity and list student responses on the board. Take about five minutes to work through this section of the activity.

Instructional Strategy

- Use the discussion method to present the topic to students.
- Use the brainstorming activity as the principal method of instruction.
- Use this activity as a small group project (4-5 students in each group).

Equipment/Supplies

1. Pencils and paper
2. Found materials—The following are examples of what kinds of things work well for this activity: a bone, spring, feather, dowel rod, piece of elastic, seashell, soda straw, match box, plastic film container, piece of rope, rock, nail, pencil, brick, mirror, etc.

Evaluation Key

Instructor evaluation of student performance on this activity should be based on participation in the project. Note that creative thinking is a difficult area to evaluate using standard grading techniques and should not be presented as an intimidating exercise which might inhibit participation in the activity.

BRAINSTORMING

Learn about the process of brainstorming as a part of the research and development process.

Objective

- To apply the basic creative thinking skills presented in this project to future problem-solving tasks

Vocabulary/Concepts Reinforced

- Brainstorming
- Creativity
- Problem solving

Equipment/Supplies

- Pencil and paper
- Found objects provided by the instructor

Introduction

Brainstorming is a form of problem solving in which two or more people work collectively to solve a particular problem by creating as many thoughtful solutions as possible. In applied research two basic thought processes are used. The first is critical thinking, in which the problem solver uses his or her analytical skills to evaluate how a possible solution might be applied to the problem. The second thought process involves imaginative thinking and creating new ideas to be used in the solution of a problem.

Brainstorming relies on the second thought process. It is based on the quantity rather than the quality of ideas being generated. In the brainstorming session members are not concerned with developing one perfect solution to the problem but with listing as many ideas as possible. The members of the brainstorming group will begin listing ideas that are obvious and easily perceived, then begin building upon these to create ideas that are not so obvious. One good rule of thumb to follow is to be creative and imaginative in suggesting ideas.

In order for the brainstorming session to be productive it is important to establish a few ground rules. Brainstorming groups should be organized with a leader who can record ideas and keep general order among the group. The following rules for brainstorming sessions were listed in Alex F. Osborn's book *Applied Imagination*.

1. Criticism is ruled out.
2. The wilder the idea the better.
3. Quantity is desired—the greater the number of ideas, the greater the likelihood of good results.
4. Combination and improvement are sought. This relates to improving on ideas that are presented.

Brainstorming, however, takes some practice to become a useful tool in the problem-solving arena. A good example of how brainstorming works is to take a common object such as a pencil and develop a list of uses for it. Here is a very

common device which we all know how to use and usually have in our possession most of the time. Take your pencil in hand and study it. It is relatively easy to analyze because it is made up of some relatively common components—wood, brass, graphite, and rubber. Now make a list of as many uses as possible that you can think of for the pencil or any part of the pencil.

Procedure

Apply the brainstorming concept to a group problem-solving situation. Begin by dividing the class into groups of 4-5 students. Each group should then choose a leader who can record ideas and ensure that the rules listed above are followed. Your instructor will give your group an object. Each group will then list as many uses as possible for the object. Toward the end of your class period the instructor will ask each group leader to display the object and then read the list of uses developed by the group.

Upon completion of the activity your instructor will ask the class how brainstorming can be applied to larger problems within your instructional area.

Evaluation

Evaluation of student performance will be based on participation in the activity and any additional criteria established by the instructor.

Support Materials

- Osborn, A. F. *Applied Imagination.* 3d ed. New York: Scribner's, 1979.

IMITATION, ADAPTATION, AND INNOVATION

Essential Elements: Common: 8
Specific: 4, 11
TAAS Objectives: Language Arts: RC 1-6

Activity Summary

This activity is designed to provide advanced-level students with a creative research project in which they observe the ways in which industry uses the concepts of imitation, adaptation, and innovation. The model for the activity is the automobile industry and how it utilizes these concepts in developing and marketing cars.

Teaching Tips

1. Create a bulletin board display of car photographs which illustrate the various styles and types of cars marketed. Categorize them into groups which help to illustrate the concepts discussed in the activity. Local car dealerships are a good source for pictures and literature.

Instructional Strategy

- Use a group discussion to present the topic to students.
- Use a brainstorming session to help students generate ideas.
- Use the activity as either a small group or individual project.

Equipment/Supplies

Any use of equipment or supplies will depend on how instructors present the topic.

Evaluation Key

Evaluation of student performance on this activity should be based on participation in and completion of the activity.

IMITATION, ADAPTATION, AND INNOVATION

Explore the use of imitation, adaptation, and innovation in the development of industrial products.

Objectives

- To recognize the use of imitation, adaptation, and innovation in the development of industrial products and processes

Vocabulary/Concepts Reinforced

- Imitation—The process by which one company imitates either a product or process used by another company.
- Adaptation—The process by which a company adapts a process or product used by another company to fit or improve its own productivity.
- Innovation—The process by which a company develops new technology to improve its productivity.

Background Information

Industry and technology depend heavily on the creative development of new processes and products to support their existence. They also rely on existing technology which has proven itself in either performance or profitability. The success of a company to exist in today's marketplace depends heavily on its use of three concepts—**imitation**, **adaptation**, and **innovation**—to bring its products to the marketplace and remain competitive.

One area within technology where these concepts are clearly illustrated is the automobile industry. Because competition within this industry is so intense each company must present itself to the car-buying public as the one with the most technically advanced and stylish line of vehicles at the best possible value.

Imitation is used by automobile manufacturers to take advantage of either a style or concept that has a proven market. When Chevrolet developed its Corvette sports car, Ford imitated the concept with its own design in the Thunderbird. When Ford came out with the Mustang, General Motors answered with the Camaro and Firebird. Other examples include an industry-wide series of Mercedes look-alikes. These are clear examples of how companies in an industry imitate one another to bring products to market.

Adaptation is used by manufacturers to take a concept which is common to one area and make it fit into another. A good example of this concept in use is the adaptation of diesel engines, which were common in large trucks and heavy equipment, for use in both passenger cars and small trucks. This adaptation became especially popular during the oil crisis of the early 1970s when gasoline prices skyrocketed. Car manufacturers offered diesel engines as an optional power plant in almost any style of vehicle. This adaptation has proven very valuable to both the manufacturers and private consumers.

Innovation is another important element of the automobile industry. Innovation has to do with developing new technology such as four-wheel steering, mid-engines, air bags, sunroofs, radial tires, etc., that have a high degree of marketable

appeal. Automobile manufacturers are constantly researching and developing innovative technology which they can tie into marketing new products. Innovation requires a great deal of research and creative thinking by marketing specialists, engineers, designers, and technicians.

Introduction

How can these concepts be applied to a study of industry and technology? As advanced students become more involved in their particular areas of interest, they should be able to determine that technology is interrelated with industrial applications. This application can be made to all types of industries involved in technology, manufacturing, and marketing.

In this activity students will select an industry and research how the concepts of **imitation, adaptation,** and **innovation** can be observed within it. Students will prepare a written technical paper and present their findings to the class for discussion.

Procedure

1. Select a topic for your research project from the list provided by the instructor or one which the instructor approves.
2. Research the methods of imitation, adaptation, and innovation that are used within that area of technology.
3. Prepare a short research paper which supports your findings on the topic.
4. In a class discussion of the concepts, present your findings for discussion.

Evaluation

Instructor evaluation of the activity will be based on student participation and completion of the project. Additional criteria may be used as necessary.

WRITING A TECHNICAL PAPER

Essential Elements: Common: 7-10
Specific: 1, 7, 10, 11

TAAS Objectives: Language Arts: RC 1-6
WC 1-7

Activity Summary

This activity is intended to provide research and development students with a basic format for writing a technical paper. Because many of the learning activities in the research and development area will include a written technical paper, it is recommended that this activity be included early in the course before students become too involved in their independent study activities.

Teaching Tips

1. Read through the entire activity before releasing to students.
2. Provide adequate research material for your particular instructional area, and arrange for the school librarian to help with resources available in the library.
3. Provide some instruction time for teaching students to use a word processing program and a personal computer if available.
4. Emphasize the importance of clear communication through technical report writing.
5. As your students become involved in technical paper writing, you may want them to emphasize the separate levels of the Technology Systems Model. Use these levels where appropriate:
    a. Resources
    b. Processes
    c. Impacts
    d. Applications

Instructional Strategy

- Use this technical writing activity as an individual or group project as needed.
- Use the technical writing activity in conjunction with other activities as necessary.
- The technical paper serves as an instructional methodology and should be adjusted to meet the needs of individual students. Avoid having a single set of criteria for all students, but adjust the level of difficulty as needed. Technical papers might very well range in complexity from a single handwritten page to a lengthy research paper; tailor it to meet individual needs.

Equipment/Supplies

1. Personal computer with word processing program and printer, if available
2. Pencils, pens, paper as needed

Evaluation Key

Generally, the technical paper is written to support either an individual or group project. The paper should conform to the standard research paper format as described in this activity guide. Although the format should be fairly consistent, the length of the paper may vary according to individual teacher requirements. In some cases the technical paper may be a full-scale research paper, while in others it may be a project summary report.

Support Materials

Develop a reference area within your instructional lab. Provide access to a variety of textbooks, trade magazines, and any other reference materials that might be useful to students in their independent study.

WRITING A TECHNICAL PAPER

Learn to write a basic technical paper to support either individual or group problem-solving activities.

Objectives
- To write a technical paper using preestablished criteria and present the paper in an acceptable format
- To apply the rules of correct English usage.

Vocabulary/Concepts Reinforced
- Hypothesis—A tentative statement made to draw out and test its logical or empirical consequence.
- Research—The method of testing a stated hypothesis.
- Technical writing—Written material used to report the results of research or to communicate technical information between individuals involved in industry and technology.

Equipment/Supplies
- Personal computer with word processing program and printer, if available
- Writing pens, pencils, and paper as needed
- Technical report writing form

Introduction
Generally, some type of technical report writing is required of those working in industrial jobs where employees need to share ideas, propose new products or processes, or report on their job-related activities. It is important, therefore, to become familiar with the basic process of writing and presenting a technical report. As you work through various activities in the research and development areas, you will be required to complete a technical report to describe and summarize what you have discovered.

Begin by reading through the following background information and become familiar with the basic report writing steps.

Background Information
Technical writing is a basic communication process used in most areas of industry and technology. Technical writing may be as simple as writing an improvement suggestion to a company or as complex as a full-scale product evaluation. Whatever its intended purpose, the technical paper is an important link to the many levels of communication found in manufacturing and production industries.

Because of the ever-increasing amount of technical information being generated in our society, it has become nearly impossible for individuals to keep up with all of the information in a particular area. It is, therefore, vital to the continued growth of our various technologies that we communicate technical information as clearly and efficiently as possible. The primary goal of technical writing is effective communication between interested parties. The organization of the information contained in the report is especially important. Generally, the accepted practice includes the following areas or sections:

1. Introduction (statement of the problem)
2. Procedures or method of research being conducted (if applicable)
3. Stated results
4. Discussion of findings
5. Conclusion

If the technical paper is a lengthy report, it is advisable to include an abstract at the beginning of the paper. The abstract is a brief summary of the report that gives readers a basic understanding of the material. It should include a short statement of the problem, method of research, results, and conclusions. The abstract should be limited to about 200 words and appear on a separate sheet. It is appropriate in some cases to replace the summary statement at the end of a paper with an abstract at the beginning.

The following sections should be included in your technical paper:

1. *Statement of the problem:* This section should introduce the reader to your topic. In cases where scientific research procedures are conducted, this section should include a statement about the hypotheses to be tested. The reader should be given a clear idea about your topic. An example of this section might read:

   "Building a topographic model for use with basic surveying techniques."

2. *Method:* This section should include information about what method was used to solve the problem. If it was a model construction project, for instance, the method used would be described as modeling or simulation. The writer should provide enough information about the method used for the reader to duplicate the project if necessary.

3. *Results:* This section should specify the results obtained at the end of the project. If, for example, a student is writing a technical paper to report his/her research findings on communication satellites, he/she should be able to describe these in an orderly manner.

4. *Conclusion and/or Summary:* In most technical paper writing a summary is adequate to summarize the problem, the results, and conclusions associated with the activity. If the technical paper is a more of a research paper it is advisable to use an abstract at the beginning of the paper and not include a conclusion.

Procedure
Use the preceding information to generate a written technical paper for the research and development activity that your teacher has assigned. Use the form below to help organize your paper.

Your instructor will advise you as to specific evaluation criteria, which will include the topic, procedures, and length of paper.

Technical Paper Writing Form

I. Statement of Problem

II. Method

III. Results

IV. Conclusions and/or summary

Evaluation
Instructor evaluation of this activity will be based on preestablished teacher criteria. The technical report will be used in conjunction with other activities as necessary. Your instructor will identify specific evaluation criteria, such as length of paper, topic selection, format, etc.

TECHNICAL RESEARCH REPORT WRITING

Essential Elements: Common: 2, 4, 7-10
Specific: 1, 2, 5, 7, 10, 11
TAAS Objectives: Language Arts: RC 2, 3
WC 1-7

Activity Summary
In this activity the students will gather all their data about their design into a technical report to document their research.

Teaching Tips
1. Stress neatness, spelling, punctuation, and accuracy of information.
2. Stress that this is not a research paper that would be assigned in an English class, but a report to communicate and document the solution to a technical problem.
3. A word processing program or a desktop publishing program can be used.

Instructional Strategy
- Go over each unit of the report and outline the information needed in each title.
- Encourage the students to use sketches, charts, and graphs to support written information.
- Have the students prepare a rough draft.
- Work with the English Department in your school to help the student with grammar and sentence structure.

Equipment/Supplies
1. Word processor program or desktop publishing program
2. Computer with CRT

Evaluation Key
Check spelling, punctuation, neatness, and accuracy of data.

TECHNICAL RESEARCH REPORT WRITING

Document research information through technical report writing.

Objectives
- To prepare a technical report to document research

Vocabulary/Concepts Reinforced
- Technical communications
- Pride in work
- Spelling, grammar, and punctuation

Equipment/Supplies
- Dictionary
- Computer with CRT
- Word processing program or desktop publishing program

Introduction
A technical report is used to document research. It is a written report containing information in an organized format to document activities, discoveries, and recommendations during research. The report should be written so that a person outside the field of research will have little difficulty understanding the research and recommendations.

To help in the understanding and documentation of the report, sketches, charts, and graphs should be used. These give the reader a quick and convenient way to understand the ideas, results, and recommendations laid out in the research.

The paper should be divided into the following chapters or units: identifying the problem, background data, preliminary ideas, refinement and final designs, analyzing the designs, and recommendations.

Procedure
1. Collect and organize all data and information.
2. Write a rough draft.
3. Have the rough draft checked for spelling, grammar, and punctuation.
4. Write a final draft.
5. Type final copy.
6. Draw all sketches, charts, and graphs.

Evaluation
You will be graded on the following:
1. Spelling
2. Grammar
3. Punctuation
4. Neatness and accuracy of sketches, charts, and graphs
5. Accuracy of information
6. Turned in on time

Periodic Goal

Research & Development

Student: _____

Project Title: _____

_____

_____

Submission Date: _____ Evaluation Date: _____

Approval: _____

Expectations	Evaluation
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
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DESIGNING TECHNICAL DATA POSTERS

Essential Elements: Common: 9-10
Specific: 7
TAAS Objectives: Language Arts: WC 1, 2

Activity Summary

This activity is designed to be used by advanced-level communication graphics students to design and produce technical data charts for use in the communication graphics lab. Students will produce charts for such things as film development, video camera setup, steps for screen printing, etc. Although the activity is intended for communication graphics students, it can be adapted to any of the instructional areas as needed.

Teaching Tips

1. Provide students with several ideas for areas where technical data charts are needed.
2. Review the principles of composition and design that might help students organize their ideas.

Instructional Strategy

- Use the discussion method to present the topic to students.
- Use the activity as either an individual or small group project.

Equipment/Supplies

1. Posterboard in a variety of colors
2. Computer with graphics software
3. Colored pens as necessary
4. Drawing boards, T squares, triangles, etc.
5. Laminating machine

Evaluation Key

Instructor evaluation of student performance on this activity will be based on the following:

1. Use of visual design elements
2. Craftsmanship in handling materials
3. Effectiveness of communicating technical data

DESIGNING TECHNICAL DATA POSTERS

Design and produce posters which help illustrate technical information.

Objectives
- To convert technical information into an easily understood graphic presentation
- To use the basic principles of design and composition to present technical data

Vocabulary/Concepts Reinforced
- Visual communication
- Graphic design
- Composition

Equipment/Supplies
- Posterboard in a variety of colors
- Computer with graphic arts program
- Colored pens and pencils
- Drawing board, T squares, triangles, etc.
- Laminating machine

Introduction

Graphic representation of technical data is often an efficient method of communication. Properly designed wall charts or posters can greatly improve the efficiency of relaying information to students in classrooms or technology labs. Information posters are also useful and effective in the workplace and can be found in a variety of situations.

In this activity students will select some form of technical data that is used on a continuing basis by students in a lab setting and create a poster which clearly illustrates that data. This information may be directions for the use of a particular machine or steps in a process. Examples include things such as operating a video camcorder, processing a roll of photographic film, or mixing chemicals for the darkroom.

Procedure

1. Discuss the topic with your instructor and agree on a topic or idea for your poster.
2. Assemble the technical data that will be presented on the poster.
3. Make several thumbnail sketches which roughly present the information.
4. Discuss your designs with the instructor.
5. Select a design that will best illustrate the information.
6. Complete a comprehensive layout of the design which is a more detailed drawing of the illustration. Discuss color selection and lettering style.
7. Make any necessary refinements to the poster and have your instructor approve the changes made.

Evaluation
Teacher evaluation of student performance on this activity will be based on participation and completion of the activity.

RESEARCH AND DEVELOPMENT—PROBLEM IDENTIFICATION

Essential Elements: Common: 1, 8-10
Specific: 1, 2, 3, 6, 11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is the first in a series of activities designed for use by students to develop a basic foundation in the technical problem-solving process. Each of these activities is intended to be used as a one-day lesson on a specific stage of the process. They can, however, be combined where necessary if you choose to spend more than one day per activity. This activity covers the first stage, Problem Identification. This is the jumping-off point from which you and your students will become systematically involved in the research and development process.

In this activity students will develop a topic for a problem and justify the need for solving it. These problems should be limited to the ability level of the student and the time frame of the activity. You may wish to provide your students with a list of possible topics from which they can choose. It is recommended that you have your students work in small groups throughout the series of activities.

Teaching Tips

1. Read through this activity and become familiar with its scope before presenting it to students.
2. This activity is part of a sequential set. Encourage students to work through the complete set before attempting any of the individual activities.
3. Develop a bulletin board display which illustrates the problem-solving process.
4. The accepted model for problem solving is the Systems Model for Problem Solving which is found in much of the current literature on the subject. Teachers should become familiar with its format.
5. Students will respond better to participation in this activity if they can plan for problems that have some practical meaning to them.
6. Develop a list of problems or topics which your students can use to generate ideas.

Instructional Strategy

- Use this activity as either a small group or individual project.
- Use group discussions to present the activity.
- Use the brainstorming technique to generate ideas.

Equipment/Supplies

1. Student worksheet

Evaluation Key

Evaluation of student performance should be based on participation in the class discussion and completion of worksheet.

RESEARCH AND DEVELOPMENT—PROBLEM IDENTIFICATION

Explore the first component of the research and development process.

Objectives

- To discuss the problem-solving process in terms of the recommended stages of development
- To discuss problem identification as the first stage in this process
- To justify the need for solving a technical problem

Vocabulary/Concepts Reinforced

- Problem Solving—The systematic process of solving, a technical problem which uses the sequence of problem identification, evaluation of specifications, development of a solution, utilization of the solution, and analysis of the results.
- Problem Identification—This is the first stage of the problem-solving process. In order to solve the problem, we must clearly understand what the problem is.

Equipment/Supplies

- Student worksheet

Introduction

In the systematic process of technical problem solving the first stage is the identification of the problem. This is the stage at which the researcher must identify specifically what the problem is. The narrower the scope of the problem or the more defined the problem is, the easier it is for the researcher to begin the solution process.

Problem identification may be presented in any one of several forms. In some cases problem identification may be a personal response to something that has a direct impact on the researcher. In other cases the problem may be the result of marketing research. Still others may be a complex series of problems associated with a single technical goal. However the problem is presented, it is the first stage in the sequence of problem solving.

In this activity students will select a topic for a possible problem and apply a set of justification questions to the topic. Each student or group will then present its problem and justification in a class discussion.

Procedure

Begin this activity by selecting a problem that you feel is worthy of your effort. This problem may be one which you choose or one that is presented to you by your instructor. Your task for this particular activity is to justify the practicality of attempting a solution to the problem.

After you have selected a topic for your problem, use the attached student worksheet to justify your selection. When you have completed the worksheet, your instructor will ask you to participate in a group discussion and present your problem. Each member of the class should provide feedback on other groups or members of the class.

Evaluation
Evaluation of student performance will be based on participation in the class discussion and completion of the worksheet.

Problem-Solving Worksheet—Problem Identification

The purpose of this worksheet is to help the students establish a clearly defined problem which they can use as the topic for either a group or individual project. Complete this worksheet and use this information in a class discussion both to share your ideas on the subject and receive ideas from other members of your class.

1. Name of problem: _____

2. Brief description of the problem: _____

   _____

   _____

3. Is the problem practical? (Explain) _____

   _____

   _____

4. Who will benefit from the solving of this problem? (Explain)

   _____

   _____

5. Are there sublevel problems that must be addressed before a final solution can be attempted?

   _____

   _____

   _____

6. What resources are available? _____

   _____

   _____

   _____

7. Suggested modifications to topic: _____

   _____

   _____

   _____

RESEARCH AND DEVELOPMENT—ANALYZING SPECIFICATIONS

Essential Elements: Common: 1, 10
Specific: 1-3, 6, 10, 11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is the second in a series of activities designed for use by students to develop a basic foundation in the technical problem-solving process. Each of these activities is intended to be used as a one-day lesson on a specific stage of the process.

The second activity covers the Analysis of Specifications stage. This is the jumping-off point from which you and your students will become systematically involved in the research and development process.

Teaching Tips

1. Read through this activity and become familiar with its scope before presenting it to students.
2. This activity is the second in a sequential set. Encourage students to work through the complete set before attempting any of the individual activities.
3. Develop a bulletin board display which illustrates the problem-solving process.
4. The accepted model for problem solving is the Systems Model for Problem Solving which is found in much of the current literature on the subject. Teachers should be familiar with its format.

Instructional Strategy

- Use this activity as either a small group or individual project.
- Use group discussions to present the activity to students.
- Use the brainstorming technique to generate ideas.
- Use student worksheet.

Equipment/Supplies

1. Student worksheet

Evaluation Key

Evaluation of student performance should be based on participation in the class discussion and completion of the worksheet.

RESEARCH AND DEVELOPMENT—ANALYZING SPECIFICATIONS

Explore the second component of the the research and development process.

Objectives

- To discuss the problem-solving process in terms of the recommended stages of development
- To discuss the importance of specifications analysis as the second stage in the problem-solving process

Vocabulary/Concepts Reinforced

- Problem Solving—The systematic process of solving a technical problem which uses the sequence of problem identification, evaluation of specifications, development of a solution, utilization of the solution, and analysis of the results.
- Problem Identification—This is the first stage of the problem-solving process in which the problem is clearly identified.
- Specifications Analysis—This, the second stage of the problem-solving process, relates to the careful evaluation of the design criteria. This stage should answer all of the requirements of the problem. The specifications should answer typical design questions such as what materials can be used, maximum and minimum sizes, colors, shapes, location, etc.

Equipment/Supplies

- Student worksheet

Introduction

Once we have identified the problem to be solved, we must either create or evaluate the criteria that will guide us through to the solution. The specifications will list the basic requirements for the problem and are sometimes called the design criteria. The specifications will list such things as the exact function of the design, how big it should be, how much it should weigh, what materials will be used, etc.

Establishing the specifications is very important. Think about your class working on a problem-solving project to design a doghouse for a 90-pound Labrador retriever named Bud. If each member of your class was given the task to design a doghouse for Bud with no other information than that Bud is a dog and weighs 90 pounds, there would be a wide variety of doghouses. Identifying a few basic specifications, however, would help to narrow the possible solutions. If we were told that the doghouse needed to be 4 feet long, 3 feet wide, and 3 feet high, we would have a few more clues. If we add other specifications, such as the material to be used, the size of the door, the pitch of the roof, the color of the paint, etc., we greatly reduce the possible design solutions.

Specifications are important. Think for a moment about the specifications that must be established for designing and building a nuclear power plant. The list of specifications would fill a room the size of your basketball gym from floor to ceiling with detailed drawings and typewritten descriptions for every component—from the material that goes into the steel to fabricate the nuts and bolts in the superstructure to the color of the wallpaper in the employees' lounge.

Procedure
Use the problem that you identified in the previous activity to complete the following worksheet relating to specifications. When you have completed the worksheet, your instructor will ask you to participate in a class discussion on the topic.

Evaluation
Evaluation of student performance will be based on participation in the class discussion and completion of the worksheet.

Problem-Solving Worksheet—Analyzing Specifications

Stated Problem: _____

Brief Description: _____

_____

Specific Function: _____

_____

Materials: _____

_____

_____

Size and Shape Description (attach sketch if necessary):

_____

_____

_____

_____

Workmanship: _____

_____

Colors: _____

_____

Finishes: _____

_____

Other Information as Needed: _____

_____

RESEARCH AND DEVELOPMENT—DEVELOPING A SOLUTION

Essential Elements: Common: 1, 10
Specific: 1-9, 11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is the third in a series of five activities designed for use by students to develop a basic foundation in the technical problem-solving process. Each of these activities is intended to be used as a one-day lesson on a specific stage of the process.

This activity focuses on Developing a Solution. At this stage of the process, students will have defined the problem and evaluated the specifications. In this activity students will use their creativity to develop a solution to the problem.

Teaching Tips

1. Read through this activity and become familiar with its scope before presenting it to students.
2. This activity is the third in a sequential set. Encourage students to work through the complete set before attempting any of the individual activities.
3. Develop a bulletin board display which illustrates the problem-solving process.
4. The accepted model for problem solving is the Systems Model for Problem Solving which is found in much of the current literature on the subject. Teachers should be familiar with its format.

Instructional Strategy

- Use this activity as either a small group or individual project.
- Use group discussions to present the activity to students.
- Use the brainstorming technique to generate ideas.
- Use the student worksheet.

Equipment/Supplies

1. Student worksheet

Evaluation Key

Evaluation of student performance should be based on participation in the class discussion and completion of the worksheet.

RESEARCH AND DEVELOPMENT—DEVELOPING A SOLUTION

Explore the third stage of the research and development process through developing a solution to a problem.

Objectives
- To discuss the problem-solving process in terms of the recommended stages of development
- To discuss the importance of developing a solution as the third stage in the problem-solving process
- Use brainstorming techniques in the solution of basic technical problems

Vocabulary/Concepts Reinforced
- Problem Solving—The systematic process of solving a technical problem which uses the sequence of problem identification, evaluation of specifications, development of a solution, utilization of the solution, and analysis of the results.
- Problem Identification—This is the first stage of the problem-solving process in which the problem is clearly identified.
- Specifications Analysis—The second stage in the problem-solving process in which the design criteria are evaluated.
- Developing a Solution—The third stage in the problem-solving process in which an attempt is made to solve the problem based on a given set of specifications.

Equipment/Supplies
- Student worksheet

Introduction
After the specifications and design criteria have been established, the next stage in the problem-solving process is to apply these facts to the solution of the problem. The development of a solution is a set of progressive steps which often result in several good ideas that will solve the problem. Rarely is there a single solution to any problem. More often than not, a set of alternative solutions is developed with the most practical solution chosen for use.

Reaching a solution can be accomplished by approaching it from different angles. In some cases the solution is reached because of the background experiences of the researcher. In other cases the solution is achieved through trial and error procedures, and in some cases the solution is the result of spontaneous insight into the problem. Still others are the result of brainstorming ideas that result in the solution. And in a very few instances the solution is purely accidental.

Background Knowledge
The development of a solution is often based on what the researcher already knows about the problem. Engineers, who are typical of technical problem solvers, have a background in the areas in which they work. When they are presented with a problem, they are able to draw from their background knowledge on the subject and apply this knowledge to finding the solution. Think about the many different fields of engineering. Each is a specialized area of problem solving with engineers trained to solve problems in their own specialties.

Trial and Error

In many problem-solving situations the best way develop a solution is to try several possibilities. This is the trial and error method. It is practical for those situations where resources and time permit. This method relies on the application of several solutions, analyzing the results, and making a final selection which may include elements of several initial solutions. The trial and error method is an important problem-solving method, but it does require additional time and resources to be useful.

Insight

Insight has to do with a spontaneous thought about the solution of a particular problem. It has been said that Einstein discovered the final link in his theory of relativity one morning while shaving. Insight probably plays a major role in many areas of problem solving; however, it is usually tied with one or more of the other solution-finding methods discussed in this activity.

Brainstorming

Brainstorming is another powerful method of problem solving. It relies on creative thinking skills. Generally, brainstorming is done by several people who list as many solution possibilities as they can think of. Every idea is a good idea, and all of them are written down no matter how off-the-wall they may seem. After the brainstorming session is complete, the group members review all of the responses and select a few that can be developed in further detail.

Accidental Discovery

Another problem-solving method that sometimes occurs is accidental discovery. Accidental discovery may be the result of a researcher trying to find the solution to a problem and accidentally stumbling onto the solution that works for his particular problem. In other cases, accidental discoveries occur when one problem solver stumbles onto a solution that she knows will work for another problem.

Procedure

Using the problem and the specifications that you identified in the previous activities, complete the following worksheet relating to solving the problem. When you have completed it, your instructor will ask you to participate in a class discussion on the topic.

Evaluation

Evaluation of student performance in this activity will be based on completion of the worksheet and participation in the class discussion.

Problem-Solving Worksheet—Developing a Solution

Stated Problem: _____

Brief Description: _____

_____

Specifications: _____

_____

_____

Method of Solution: (experience, trial and error, insight, brainstorming, accidental discovery)

Select one or more of the methods listed above, and describe how it will be used in the development of a solution for your problem. Use the space below to write down your justification for the methods you have selected.

_____

_____

_____

_____

_____

_____

_____

RESEARCH AND DEVELOPMENT—PILOT-TESTING THE SOLUTION

Essential Elements: Common: 1, 10
Specific: 1-3, 5-9, 11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is the fourth in a series of activities designed for use by students to develop a basic foundation in the technical problem-solving process. Each of these activities is intended to be used as a one-day lesson on a specific stage of the problem-solving process.

The fourth activity deals with pilot-testing the solution. This is the stage where the solution is tested to see whether or not it performs or otherwise satisfies the requirements of the problem. Pilot-testing is a vital link in the problem-solving process.

Teaching Tips

1. Read through this activity and become familiar with its scope before presenting it to students.
2. This activity is the fourth in a sequential set. Encourage students to work through the complete set before attempting any of the individual activities.
3. Develop a bulletin board display which illustrates the problem-solving process.
4. The accepted model for problem solving is the Systems Model for Problem Solving which is found in much of the current literature on the subject. Teachers should be familiar with its format.

Instructional Strategy

- Use this activity as either a small group or individual project.
- Use group discussions to present the activity to students.
- Use the brainstorming technique to generate ideas.
- Use the student worksheet.

Equipment/Supplies

1. Student worksheet

Evaluation Key

Evaluation of student performance should be based on participation in the class discussion and completion of the worksheet.

RESEARCH AND DEVELOPMENT—PILOT-TESTING THE SOLUTION

Explore the fourth stage in the problem-solving process by testing the solution against the specifications.

Objectives

- To discuss the problem-solving process in terms of the recommended stages of development
- To discuss the importance of pilot-testing the solution as the fourth stage in the problem-solving process
- To use brainstorming techniques in the solution of basic technical problems

Vocabulary/Concepts Reinforced

- Problem Solving—The systematic process of solving a technical problem which uses the sequence of problem identification, evaluation of the specifications, development of a solution, pilot-testing the solution, and analysis of the results.
- Problem Identification—The first stage in the problem-solving process in which the problem is clearly identified.
- Specifications Analysis—The second stage in the problem-solving process in which the design criteria are evaluated.
- Developing a Solution—The third stage in the problem-solving process in which an attempt is made to solve the problem based on the given set of specifications.
- Pilot-Testing—The fourth stage in the process in which a solution to the problem is tested to see whether or not it performs as intended.

Equipment/Supplies

- Student worksheet

Introduction

When a solution to a technical problem has been developed, the next stage in the process is to test it against the stated performance standards or specifications. Pilot-testing of a solution is important in that it provides the feedback necessary to evaluate the solution to observe whether or not it will actually do what it is supposed to do.

Pilot-testing is done through the development of working models or prototypes. Depending on what the solution is, the model is tested accordingly. A model or prototype may be as complex as an oil refinery or as simple as a paper airplane. Pilot-testing may also include testing several variations of a solution by distributing a prototype into separate testing environments.

With today's powerful computer programs, pilot-testing of engineering and architectural solutions can be accomplished without having to actually build a model. The computer will perform tests for structural strength, color options, give three-dimensional and stereoscopic views, and duplicate just about any test possible under real conditions. This method of testing not only saves time and money but often is much safer than testing a device under real conditions.

Modeling can also take the form of charts and graphs and in some cases may be nothing more than a mathematical model which can calculate the performance of a solution. Typical of this type of modeling is the calculating of structural performance of certain materials in building construction. Structural engineers use this type of modeling quite often to make certain that their design work will not fail under the conditions to be used.

Procedure

Using the problem, specifications, and solution which you have identified in the previous activities, complete the following worksheet relating to testing the solution. When you have completed the worksheet, your instructor will ask you to participate in a class discussion on the topic.

Evaluation

Evaluation of student performance on this activity will be based on completion of the worksheet and participation in the class discussion.

Problem-Solving Worksheet—Pilot-Testing the Solution

Stated Problem: _____

Brief Description: _____

_____

Specifications: _____

_____

_____

Solution: _____

_____

_____

Testing Procedure: (Describe the method or methods for testing your solution. Be able to justify your selection of testing method(s) and describe what the test will actually determine.)

_____

_____

_____

_____

_____

_____

RESEARCH AND DEVELOPMENT—ANALYZING THE RESULTS

Essential Elements: Common: 1, 10
Specific: 1-3, 5-11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is the fifth in a series of five activities designed for use by students to develop a basic understanding of the technical problem-solving process. Each of these activities is intended to be used as a one-day lesson on a specific stage of the process.

This activity focuses on analyzing the results of the problem-solving process. By the time students have reached this stage they will have defined the problem, evaluated the specifications, developed a solution, and tested the solution. In this section the student will discover the importance of providing feedback to the initial problem in order to check the solution against the stated problem.

Teaching Tips

1. Read through this activity and become familiar with its scope before presenting it to students.
2. This activity is the fifth in a sequential set. Encourage students to work through the complete set before attempting any of the individual activities.
3. Develop a bulletin board display which illustrates the problem-solving process.
4. The accepted model for problem solving is the Systems Model for Problem Solving which is found in much of the literature on the subject. Teachers should become familiar with its format.

Instructional Strategy

- Use this activity as either a small group or individual project.
- Use group discussions to present the activity to students.
- Use the brainstorming technique to generate ideas.
- Use the student worksheet.

Equipment/Supplies

1. Student worksheet

Evaluation Key

Evaluation of student performance should be based on participation in the class discussion and completion of the worksheet.

RESEARCH AND DEVELOPMENT—ANALYZING THE RESULTS

Explore the fifth stage of the problem-solving process through comparing the results of the performance tests against the initial problem and specifications.

Objectives

- To discuss the problem-solving process in terms of the recommended stages of development
- To discuss the importance of developing a solution as the third stage in the problem solving process
- To use brainstorming techniques in the solution of basic technical problems

Vocabulary/Concepts Reinforced

- Problem Solving—The systematic process of solving a technical problem which utilizes the sequence of problem identification, evaluation of specifications, development of a solution, utilization of the solution, and analysis of the results.
- Problem Identification—This is the first stage of the problem-solving process in which the problem is clearly identified.
- Specifications Analysis—The second stage in the problem-solving process in which the design criteria are evaluated.
- Developing a Solution—The third stage in the problem-solving process in which an attempt is made to solve the problem based on the given set of specifications.
- Pilot-Testing—The fourth stage in the process in which a solution to the problem is tested to see whether or not it performs as intended.
- Analyzing the Results—In this stage the solution is analyzed to see if it meets the problem and specifications.

Equipment/Supplies

- Student worksheet

Introduction

After the problem solution has been tested, the next and final stage of the process is to evaluate the test results against the initial problem. This is a very important part of the process and should not be overlooked. This stage provides much-needed feedback to ensure that the solution is actually going to solve the problem. This process will allow us to make adjustments or fine-tune the solution as necessary.

Typical of the problem-solving process is the premature decision that a solution has actually been discovered. An example of this is the medical researcher who announces that he has discovered the cure for the common cold. The solution sounds exciting, but the real fact of the matter is that he has discovered a symptomatic treatment rather than an actual cure for the cold. Had the researcher analyzed his solution tests more closely, he might have seen his mistake. It is important, therefore, to carefully study and analyze the results of solution tests to ensure that the solution is actually going to solve the problem.

Careful analysis of the results is, therefore, critical to the problem-solving process. Comparing the test results with the initial problem statement will help to either confirm or, in many cases, modify the solution so that it will in fact perform as expected.

Procedure
Using the problem, specifications, solution, and testing information that you have identified in the previous activities, complete the following worksheet relating to analyzing the results. When you have completed the worksheet, your instructor will ask you to participate in a class discussion on the topic.

Evaluation
Instructor evaluation of student performance will be based on completion of the worksheet and participation in the class discussion.

Problem-Solving Worksheet—Analyzing the Results

Stated Problem: _____

Brief Description: _____

_____

Testing Results: _____

_____

_____

_____

_____

Analysis of the Results:

A. Do the tests support the solution in relation to the originally stated problem? Explain.

_____

_____

_____

B. Do the tests support the use of each specification? Explain.

_____

_____

_____

TIME LINE

Essential Elements: Common: 2, 7, 8
Specific: 7, 8
TAAS Objectives: Language Arts: RC 1-3
WC 1, 4

Activity Summary

This activity is the first in a series of activities that will allow the student to go through the design process requirements of research and development. This first activity is intended to help the student gather data for the background research. The student will use the library to gather information about the history and evolution of flight.

Teaching Tips

1. This can be used as a group or as an individual assignment.
2. Students or groups are assigned periods or eras of time, types of aircraft (lighter-than-air or heavier-than-air), and/or historical facts.
3. Students, groups, or teacher draw a time line on butcher paper or chalkboard with each century marked off. Each student or group will then record the assigned date and information on the time line within the proper period of time.
4. Each piece of information should be presented in chronological order.
5. As each piece of data is recorded on the time line, a drawing or model of the type of aircraft can be shown along with information about the design, designer, or any other historical data.

Instructional Strategy

- This activity will reinforce library as well as research skills. Be sure to stress not only the use of encyclopedias but also the use of other references such as *Science and Technology*, *Illustrated Science and Inventions*, *The Encyclopedia of Science and Technology*, and other periodicals and reference materials.

Equipment/Supplies

1. Paper, pencil, and eraser
2. Reference materials
3. Butcher paper or chalkboard
4. Markers
5. Materials for models (students could furnish)
6. Poster board for displaying drawings (students could furnish)

Evaluation Key

1. Check the students on workmanship and quality of work.
2. Ask questions as the data is presented to check for learning.

TIME LINE

Gather and assemble in chronological order data about the history of flight.

Objectives

- To organize technical data
- To use proper library research techniques
- To investigate design improvements

Vocabulary/Concepts Reinforced

- Heavier-than-air
- Lighter-than-air
- Blimp
- Dirigible
- Aerodynamics
- Aerostatic vehicles

Equipment/Supplies

- Paper
- Pencil
- Eraser
- Poster board
- Marking pen
- Model supplies

Introduction

Throughout history, man has tried to use many different devices to move himself through the air like a bird. The first story is told in early Greek mythology about Daedalus and his son Icarus. They created birdlike wings of feathers and wax in an attempt to escape from Crete, where they were imprisoned.

The concept of using flapping wings occupied for centuries the thinking of those who dreamed of flying with the birds. Notable among those dreamers was Leonardo da Vinci. He designed a machine that transforms a person's muscle power into flapping motion.

In the 1700s some men abandoned the flapping wing concept to experiment with a different principle, that of lighter-than-air craft, the balloon. However, others experimented with another method of flying. Instead of using flapping wings or an aerostatic vehicle, they worked with a fixed wing position to attempt gliding.

The glider was the first of the heavier-than-air craft. This design led men like the Wright brothers to attempt to design a powered human-carrying aircraft. You will be expected to use the library to research and gather information to chronicle the history of flight.

Procedure

1. Using reference books in the library, look up dates and information about important events in the evolution of flight.

2. Arrange the dates in chronological order.
3. Place the dates and events on a time line to show their place in the history of flight.
4. Make a drawing or a scale model of a design as it was in history.

Evaluation
You will be evaluated on workmanship and pride in your work, as well as on your knowledge of the events you were assigned to research.

COMPUTING PERSONALIZED DEVELOPMENT TIMES

Essential Elements: Common: 8A, 8B, 9B, 10B
Specific: All
TAAS Objectives: Language Arts: RC 1, 4-6
Mathematics: C 2
PS 1, 2, 4

Activity Summary

This activity is designed to allow a student to determine his/her best processing time for a specific kind of film and developer. Students will use a densitometer (necessary for this activity) to plot the densities of their test film on a graph and then calculate normal development time.

Teaching Tips

1. This activity is only for those students who are serious enough about the quality that they will strive to remain as consistent as possible in their processing. If the students haphazardly conduct this experiment, the results will probably be useless.
2. To find a densitometer, check with a local processing lab or graphic arts/printing facility. If you have a college photography program in your area, it might have one which your students could use.
3. Explain to the student(s) that optimum development times can be calculated according to the recommended density of specific shadow or highlight areas in a negative. This test produces those shadow and highlight areas in a controlled experiment, so that the developing times can be calculated.

Instructional Strategy

- Lecture to present topic to the students.
- Assist students, when necessary, with the setup and exposing of the film under even copy lighting.
- Stress consistency and accurate record keeping.

Equipment/Supplies

1. Camera
2. Telephoto lens (if possible)
3. 18% gray card
4. Tripod or copy stand
5. Copy lights
6. Film to be tested (four rolls)
7. Processing chemicals (selected developer, fixer, photo flo)
8. Processing equipment (tanks, reels, dependable thermometer, graduates)
9. Densitometer
10. Graph paper

Evaluation Key

Evaluation of student performance should be based on the students' written records of their procedures and the results of their research. (See evaluation sheets that follow the student activity.)

COMPUTING PERSONALIZED DEVELOPMENT TIMES

Determine your own best processing time with a specific film/developer combination.

Objective

- To shoot, process, and read the densities of four rolls of film, using an 18% gray card, to determine your own best processing time, taking into account dilution, temperature, and agitation variables.

Vocabulary/Concepts Reinforced

- 18% gray card
- Density
- Contrast
- Densitometer
- Zone system
- Exposure
- Reflected light meter
- Record keeping
- Film processing

Equipment/Supplies

- Camera
- Telephoto lens (if possible)
- 18% gray card
- Tripod or copy stand
- Copy lights
- Film to be tested (four rolls)
- Processing chemicals (selected developer, fixer, photo flo)
- Processing equipment (tanks, reels, dependable thermometer, graduates)
- Densitometer
- Graph paper

Introduction

Everyone processes film a little differently. The way the chemicals are prepared, the temperature of the chemicals, the accuracy of the thermometer, the agitation of the film during processing, even the initial exposure and camera that was used will all have an effect on the final image.

To determine your own best processing time, a personalized development test can be run. It should be stressed that the results will depend on your desire and ability to be as consistent as possible with the procedures.

Once the film is processed, the density of the different negatives is plotted on a graph so that you can discover the best processing time for that film and developer combination. Changing film types or developer will negate the results of the test, so it is important to select a combination that you expect to use for a while.

In addition, the results of the test will also indicate recommended processing times for film that has been exposed in lighting conditions that were low or high in contrast.

Procedure

1. Start by setting up even copy lighting (two lights) on a Neutral Test Card (18% gray side). Place the camera on a copy stand or on a tripod. (See Diagram #1.) Be sure that there are no direct reflections or glare being reflected back into the lens from the surface of the card. Throw the card out of focus by placing the lens on infinity. If possible, use a telephoto lens and fill up the frame with the image of the card.

   Determine an exposure for normal placement of the gray card by using a reflective light meter (either the one in the camera or a hand-held meter). Write down this exposure.

2. Expose the first frame on your roll of film five *f*-stops less (closed down) than the exposure indicated in step 1. This will place the exposure on Zone 0. Be sure to write down this exposure.

3. Expose the next frame four *f*-stops less than the exposure indicated by the meter (Zone I).

4. Continue this procedure, exposing each subsequent frame one *f*-stop more than the preceding frame. Do this for a total of eleven frames. Try to keep the exposures in the middle range of shutter speeds—from 1/2 second to 1/500 of a second. Remember that the very high shutter speeds on a focal plane shutter are the first to become inaccurate. (An even better choice of shutter speeds would be from 1/30 to 1/250.) Light the Neutral Test Card so that the first exposure is around 1/125 at *f*/8 or *f*/11. It is better to change the aperture than the shutter speed for these tests, since there is usually less error in exposure when using the apertures.

5. Repeat the first four steps, exposing three additional rolls of film. Or you may place one set of exposures on each end of a 36-exposure roll and cut it in half to process. Using an entire roll for each test will provide more accurate test results.

6. Develop the first roll of film for 1/2 of the time suggested by the manufacturer of the developer.
   Develop roll 2 for 3/4 of the recommended time.
   Develop roll 3 for the normal or recommended time.
   Develop roll 4 for 1 3/4 of the suggested time.

7. After processing, read the densities for each roll on a densitometer and record them, frame by frame. Read each frame in several places and then average the readings. Example #1 would be possible readings for Kodak Tri-X in Kodak D-76.

8. Plot these densities in vertical rows above each development time on a sheet of graph paper. (See Diagram #2.)

9. Connect the bottom densities on each vertical line with a curving line. This first row is equivalent to Zone 0. Do the same for the densities representing Zone I, Zone II, etc. (See Diagram #3.) These curves should not be drawn from point to point. They should be averaged or idealized curves. After the curves are drawn, large gaps between lines or sharp angular bends should be viewed with suspicion. A density point that falls too far outside the smooth curve should probably be ignored.

10. Normally exposed and developed 35mm negatives should have a highlight density of around 1.15. Try a highlight density of around 1.20 for 120mm negatives and 1.30 for larger format negatives.

11. To determine your own development time, draw a line from the selected or appropriate highlight density (1.15) across to the Zone VIII line and down to the bottom of the graph. Note this time as your normal development time for ordinary scenes.

12. To determine a one stop or one Zone expansion (N+1) development time, find where the textured highlight density crosses the Zone VII curve. You will note that this is a longer than normal development and is used for a slightly flat scene.

13. Other expansions and contractions are determined as follows:
    N-1 is drawn to Zone IX curve (high contrast lighting).
    N-2 is drawn to Zone X curve (higher contrast lighting).
    N+2 is drawn to Zone VI curve (lower contrast lighting).

14. For these tests to be meaningful and useful, each student's procedures or habits must become standardized. (Do everything the same way every time.) Use fresh developer—use the same agitation—use the same thermometer—make sure the timer is accurate—etc. Everything must be the same. Consistency is the key!

Support Materials

- Adams, Ansel. *The Negative*. Boston: Little, Brown and Co., 1981.

Example #1

Personalized Development Test
Kodak Tri-X (exposed at ASA 200) in D-76

Roll #1 was developed for 5 minutes in D-76 diluted 1:1 at 68 degrees. The water bath and fixer were also at 68. The densities on the negatives were:

1)	.26	7)	.72
2)	.30	8)	.82
3)	.33	9)	.96
4)	.41	10)	1.08
5)	.50	11)	1.15
6)	.61		

Roll #2 was developed for 7 1/2 minutes in D-76 diluted 1:1 at 68 degrees. The water bath and fixer were also at 68. The densities on the negatives were:

1)	.27	7)	.94
2)	.33	8)	1.06
3)	.42	9)	1.17
4)	.53	10)	1.23
5)	.69	11)	1.36
6)	.83		

Roll #3 was developed for 10 minutes in D-76 diluted 1:1 at 68 degrees. The water bath and fixer were also at 68. The densities on the negatives were:

1)	.29	7)	1.10
2)	.38	8)	1.22
3)	.50	9)	1.34
4)	.62	10)	1.45
5)	.80	11)	1.58
6)	.93		

Roll #4 was developed for 17 1/2 minutes in D-76 diluted 1:1 at 68 degrees. The water bath and fixer were also at 68. The densities on the negative were:

1)	.35	7)	1.72
2)	.57	8)	1.92
3)	.76	9)	2.07
4)	1.06	10)	2.23
5)	1.30	11)	2.43
6)	1.52		

When charted on the graph (Diagram #3) the densities gave a normal processing time of 8 minutes for Kodak Tri-X at ASA 200 in D-76, 1:1, 68 degrees with agitation the first 30 seconds and then 5 seconds every 30 seconds for the remaining processing time.

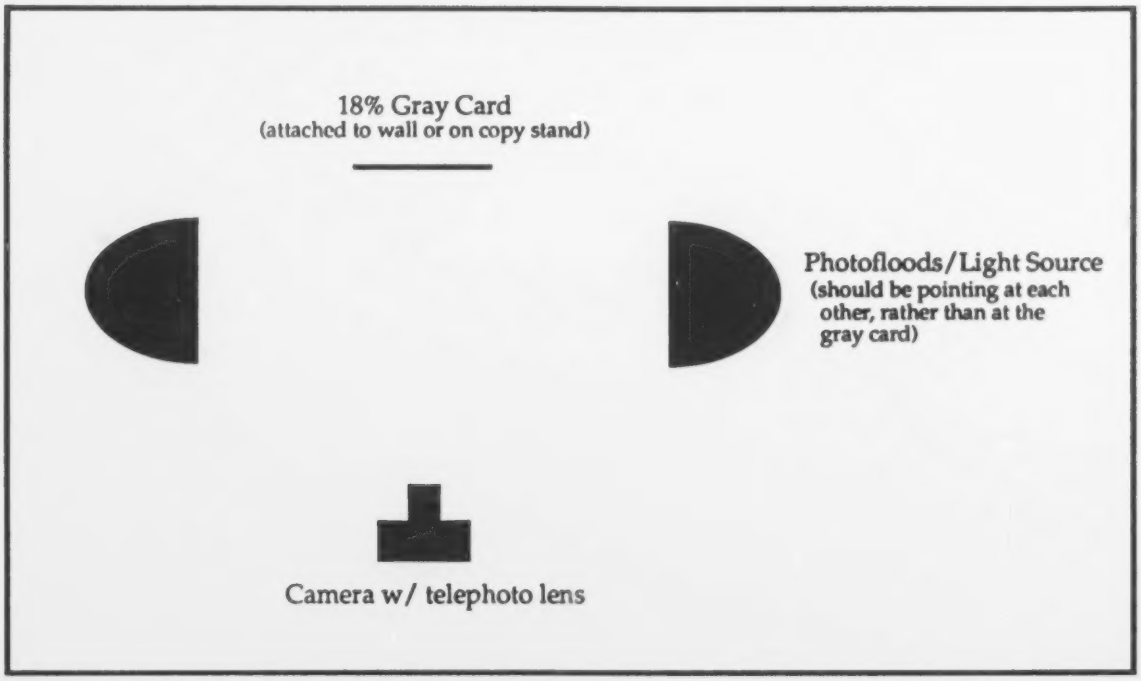

18% Gray Card
(attached to wall or on copy stand)
Photofloods/Light Source
(should be pointing at each other, rather than at the gray card)
Camera w/ telephoto lens

Diagram #1

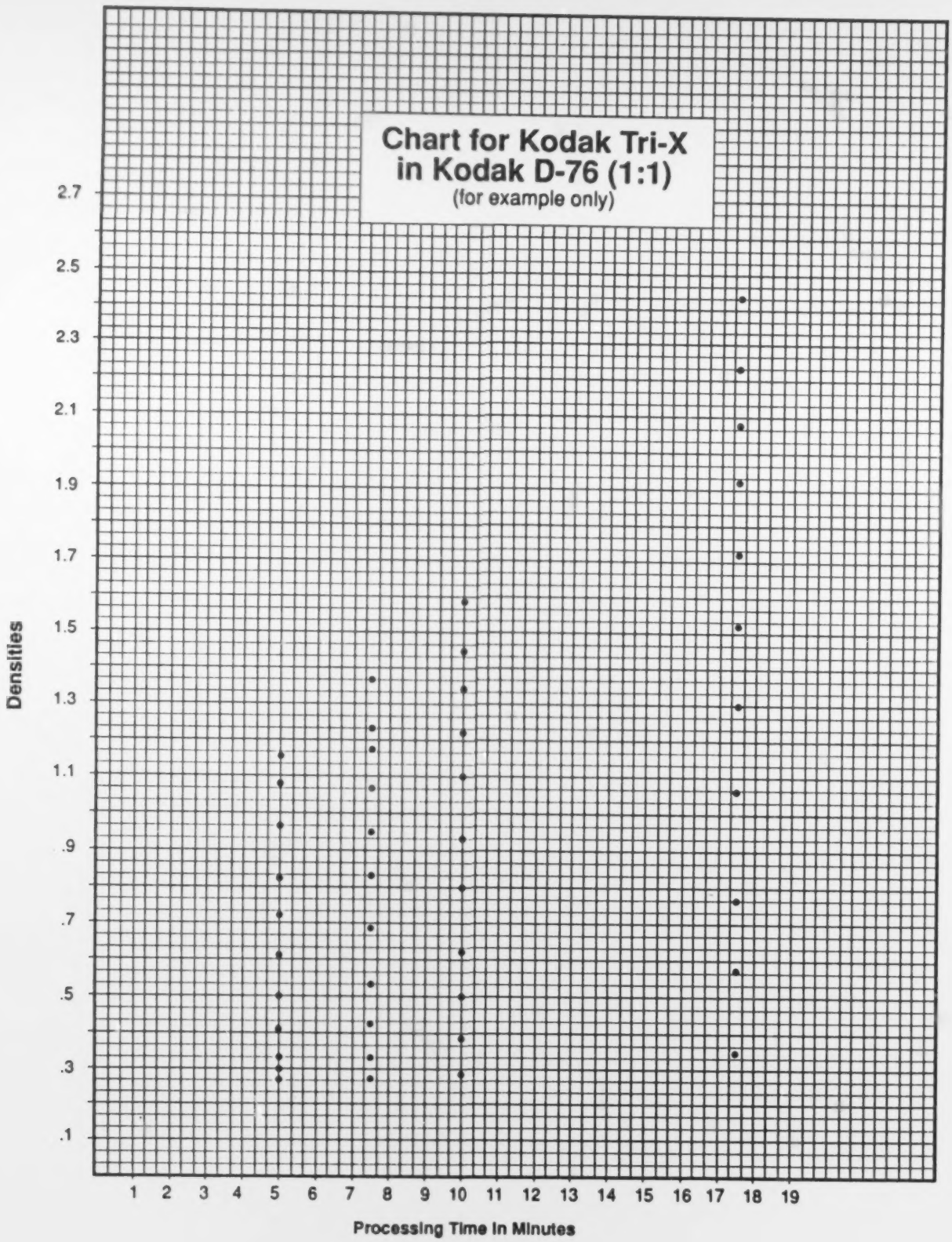


Chart for Kodak Tri-X
in Kodak D-76 (1:1)
(for example only)
Densities
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
.9
.7
.5
.3
.1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Processing Time In Minutes

DIAGRAM #2

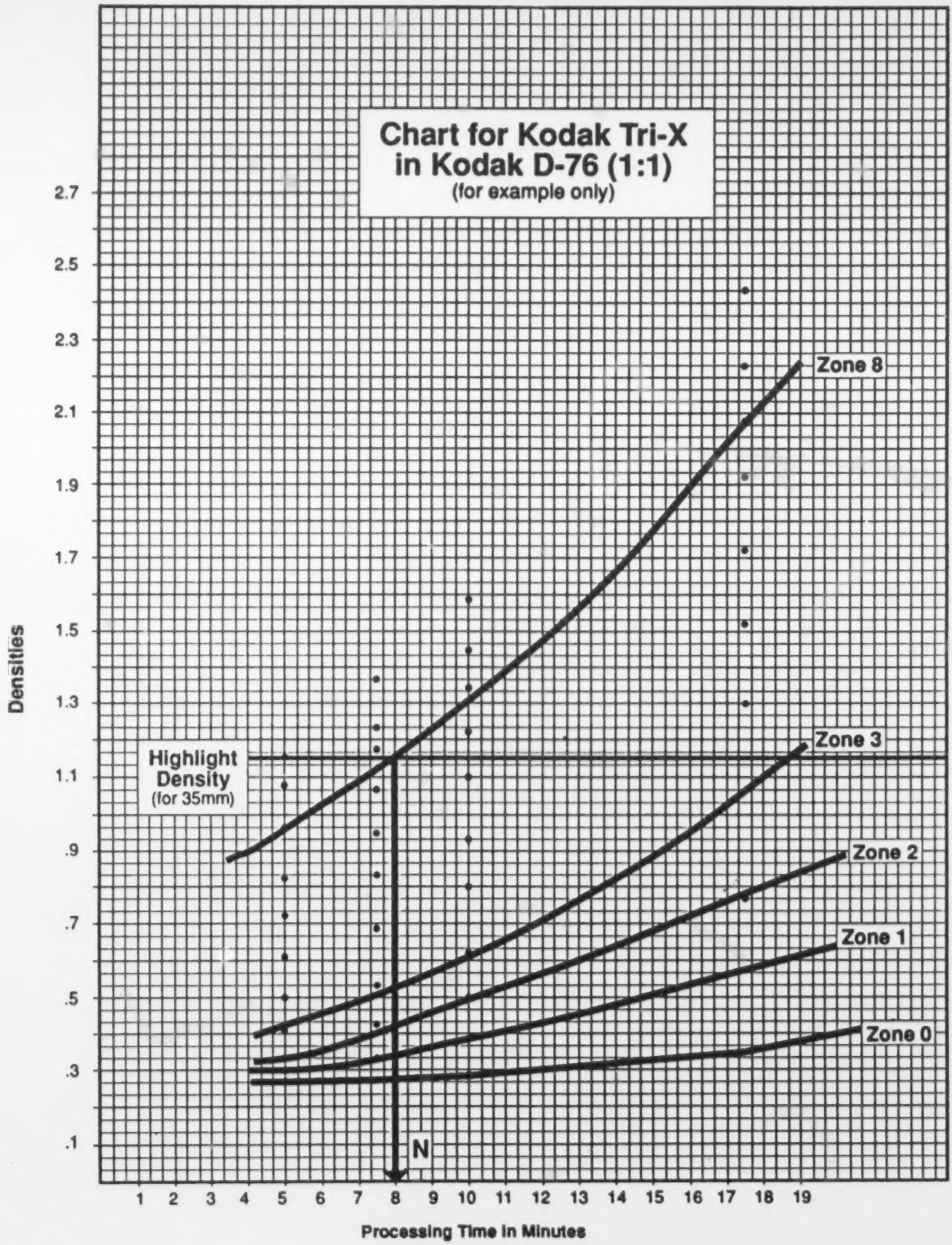
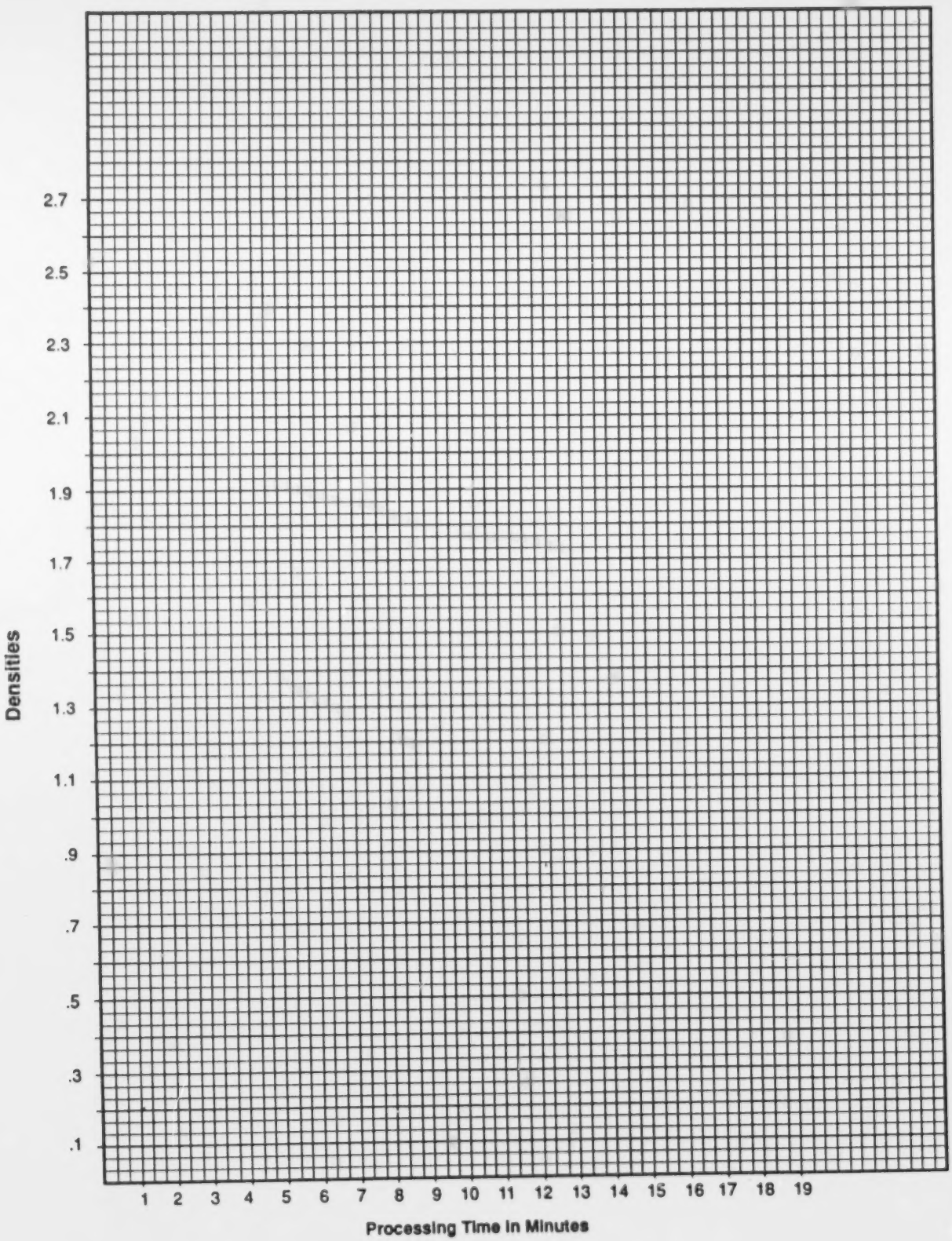


Chart for Kodak Tri-X
in Kodak D-76 (1:1)
(for example only)
Densities
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
.9
.7
.5
.3
.1
Highlight
Density
(for 35mm)
Zone 8
Zone 3
Zone 2
Zone 1
Zone 0
N
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Processing Time in Minutes

DIAGRAM #3


Densities
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
.9
.7
.5
.3
.1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Processing Time in Minutes

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DESIGN AN AIRPORT WITH FACILITIES

Essential Elements: Common: 1, 7-10
Specific: 2, 3, 5, 7, 8, 10, 11
TAAS Objectives: Language Arts: RC 1-4
Mathmatics: PS 3

Activity Summary

This activity is intended to provide students with an advanced-level research and development project in which they plan an airport Students will use the research and development problem-solving model to complete the assignment. The assignment includes designing the facility, including runways, taxiways, terminal buildings, and roadways, and presenting their design proposal as the best solution to the problem.

Teaching Tips

- Read through the entire activity before releasing to students.
- Create a bulletin board which displays various aircraft and airport designs.
- Plan a field trip to an airport.
- Develop design templates for airplanes and ground facilities as needed.

Instructional Strategy

- Lecture to present the topic to students.
- Use the activity as either a small or large group problem-solving project.
- Use simulation and modeling techniques as necessary.

Equipment/Supplies

1. Area map (laminated general area highway or city map)
2. Sectional aeronautical chart
3. Drafting equipment as necessary
4. Templates for facilities and aircraft as necessary
5. Overhead transparency markers
6. Laminated grid pattern (24" x 36")

Evaluation Key

Teacher evaluation of student performance should be based on participation in and completion of the activity.

DESIGN AN AIRPORT WITH FACILITIES

Learn how to use the research and development process to design an airport facitity.

Objectives

- To describe four types of airports
- To discuss general airport facility needs
- To discuss basic airport layouts
- To prepare a basic airport design given a set of planning criteria
- To apply the research and development problem-solving model to a practical problem

Vocabulary/Concepts Reinforced

- Airside-landside design —An airport layout in which the aviation activities are on one side of the airport and the ground activities on another.
- Air route traffic control (ARTC)—A Federal Aviation Administration facility where flight traffic is controlled outside of local airport control zones.
- Concourse—The large open areas of an airport building where passengers move about between ground transportation and arrival or departure gates. Some airports may have more than one concourse.
- Dispatching—Generally has to do with airport companies controlling the air traffic within their own company.
- Ground transportation—Generally relates to the land transportation associated with airplane travelers. It includes personal cars, buses, taxicabs, etc.
- Instrument landing system (ILS)—This is an electronic system based on a guidance beam transmitted from the approach end of a runway. The landing aircraft has a corresponding electronic device in the cockpit which identifies the airplane's relative position to the beam. The pilot can adjust the flight of his airplane, either too high, too low, too far to the right or to the left, by watching this instrument. Commercial pilots are certified in various instrument flight techniques.
- Instrument runway—All commercial airports must have one designated instrument runway available to air traffic.
- Landing pattern—Has to do with the control of air traffic near the airport. The landing pattern is an imaginary track around or near the airport by which air traffic controllers position aircraft for landing.

Equipment/Supplies

- Area map (general area highway or city map)
- Sectional aeronautical chart
- Drafting equipment as needed
- Templates for facilities and aircraft
- Laminated grid pattern (24" x 36")

Introduction

This activity is intended to provide advanced-level students with a problem-solving project in which they simulate the design of a regional airport facility. The activity involves several levels of technology, including resources, processes, impacts, and applications as they relate to building a new airport facility. Read the following background information and follow the steps as outlined in the procedure section.

Background Information

The Federal Aviation Administration is the governing body that controls all of the airports across the country. Presently there are approximately 13,000 public airports in use throughout the United States. These airports range in size from small grass landing strips to large intercontinental facilities serving a large number of commercial airlines. Airports are generally ranked in size by the number of passengers handled on a yearly basis.

The top ten airport facilities, in terms of handling passengers, in the United States are New York, Newark, Los Angeles, Chicago, San Francisco, Washington, Atlanta, Boston, Detroit, Pittsburgh, and Dallas-Fort Worth. These airports are a study in efficiency at moving people. Their primary purpose is to provide the public with a safe and efficient facility for departing or arriving aboard one of the many commercial airlines serving the airport. They are concerned with handling not only people but large numbers of aircraft as well.

One of the largest facilities in the country is the Dallas-Fort Worth (DFW) International Airport. It is spread over 17,000 acres and serves nearly 50 million passengers each year. It is also estimated that the airfreight facilities at DFW will soon handle more freight than any seaport in the world. This airport was designed with safety and efficiency in mind and serves as the hub for several commercial airlines.

Most modern airports use a **landside-airside** design or some variation of it. Basically, this design resembles a spoked wheel configuration in which the main terminal building serves as the hub of people-moving activities. The radiating spokes help to move people from this central location to the various commercial passenger gates. This hub, or terminal building, serves as a centralized area for ticket sales, baggage handling, security, restaurants, lounges, gift shops, rental car agencies, etc. In addition, there may be customs offices and facilities for handling overseas travelers. The radiating spokes serve to direct passengers from this central area to various departure and arrival gates. Many airports now use moving sidewalks and even underground light rail people movers to efficiently transport people within the airport. Airfreight facilities are much less complex. Most major airports have a separate terminal for airfreight companies. The boom of overnight express package delivery has added to the freight-handling traffic of most airports. Generally these airfreight terminals need not be as complex as passenger terminals but in some cases will need to have customs inspection stations for overseas cargo. Wherever airliners land and take off, they generally require "turnaround servicing" to take care of minor maintenance, fueling, temporary power, deicing, food service, holding tank servicing, etc. In the larger airports where commercial airlines are "home based," separate maintenance facilities are generally required. Here the major maintenance functions take place, such as airframe maintenance, interior refurbishing, and electrical and hydraulic system maintenance. A regular maintenance schedule is kept on each airplane to ensure that it is safe to fly.

The FAA also uses several facilities at major airports. Each major airport has a staff of air traffic controllers to monitor and control the movement of aircraft through designated areas. Air traffic controllers operate the control tower and air traffic control (ATC) centers at each of the major facilities. The FAA may also operate an airport weather facility in conjunction with the National Weather Service to provide current weather information for the aviation carriers.

Airport Layouts

One of the most dominant features of an airport is the system of runways and taxiways. Generally, the number of runways and the size of the runway system are determined by the air traffic at the airport. As the volume of air traffic increases, so does the complexity of the runway and taxiway system. The key factors are safety and efficiency in the movement of airplanes. The length of runways varies according to the type of airplane that must use them. Light airplanes and small commercial aircraft can use runways about 9,500 feet in length, while large commercial jetliners may require runways as long as 15,000 feet.

Runways are generally clearly marked for easy identification by pilots. A large number is painted on the approach end of the runway to identify it. The number is the whole number nearest one-tenth the magnetic azimuth, measured clockwise from magnetic north (e.g., a runway heading of 90 degrees would have a designation of runway 9). The letters L, R, and C are used to designate left, right, and center where parallel runways exist. (For example, a pair of runways running parallel north and south would have the designation 18 L and 18 R if they were being approached from the north, and 36 L and 36 R if they were being approached from the south.)

Procedure

Begin by dividing your class into groups of 2 or 3 students each. Each group is to work through this problem-solving activity as if it were an engineering company bidding on the development of the airport facility. Each group will base its design on the criteria given below. When its plan has been completed, the group will present its proposal to the class as if the class were a local governmental planning board. Each group should be able to support its design proposal with a well-thought-out plan based on efficiency and economy. Use the problem-solving model to help organize the project.

Use the laminated grid pattern to help in designing your layout. The grid pattern represents a scale of 1" = 500'. Each individual small square is 50' x 50'. Use the overhead marking pens to draw your design on the grid pattern. These pens will be easy to erase should corrections need to be made. Use various colors to highlight individual components of the plan if needed (e.g., parking facilities, automobile traffic routes, etc.).

As your group begins to piece together this problem-solving activity, you need to pay particular attention to the basic elements of the problem-solving model. If your group is not familiar with the model, it should review the following steps and organize the project around this basic structure.

1. Define the problem.
2. Evaluate the specifications.
3. Develop a set of possible solutions.
4. Select the best possible solution.
5. Utilize the selection.
6. Observe the results and provide feedback or compare them to the original goals.

Design Criteria

A. FACILITIES

The facility requirements are outlined below. Special attention should be given to the efficient handling of both incoming and outgoing automobile traffic. Three facilities will be needed for this airport: a commercial aviation terminal, a

general aviation terminal, and an airfreight terminal. These may or may not necessarily be in the same spot. Remember, however, that you are designing the airport for efficiency and economy, so try to keep the design as simple as possible.

1. Commercial Aviation:
   a. Terminal Building—A minimum of 500,000 square feet is required to handle all ticketing and commercial aviation administration functions. The terminal will also handle all baggage, rental car, restaurant, and similar activities.
   b. A minimum of 25 gates will be needed to handle the estimated number of commercial flights. Note: Use the green airplane symbols to represent each of the 25 airplanes. The 300' radius circle represents the effective handling space around the aircraft.
2. Airfreight Aviation:
   a. Terminal Building—Two 250' x 1000' buildings will be required.
   b. A minimum of 6 gates will be needed to handle the projected air freight traffic. Use the orange airplane symbols to represent the ground spacing requirements.
3. General Aviation:
   a. Terminal Building—One 250' x 100' building will be required. Five aircraft storage and maintenance hangers (250' x 500') will also be needed.
   b. For spacing purposes use the blue airplane symbols to represent 30 small general aviation aircraft. The entire facility should be able to handle a minimum of 250 aircraft.
4. Miscellaneous:
   a. Tower/Air Traffic Control Center (250' x 500')
   b. FAA Weather Station (250' x 500')
   c. Airfield Fire Station (250' x 500')

B. RUNWAYS / TAXIWAYS / RAMPS

1. Runways: Two main runways (parallel) 15,000' long will be required to handle the primary commercial traffic. These two runways will run directly east and west to facilitate the regional prevailing winds. Runway width will be figured at 500'. Two secondary runways (parallel) 9,500' long will be required to handle the general aviation and secondary commercial traffic. These two runways will need to run directly north and south.
2. Taxiways: Design taxiways as needed. Remember, however, that they are expensive to build, and think efficiently as you plan your layout. Taxiway width should be figured at 250'.
3. Ramps: To handle aircraft movement and parking, the ramps should be designed to a minimum of 1000' wide sections. This will allow for a clear space of 500' beyond parked aircraft for ground movement.

C. GENERAL REQUIREMENTS

1. Roadways: Access roadways should tie in directly to existing systems. Refer to the regional highway map for roads which can be used to handle (they can be modified) large volumes of traffic into and out of the city. Remember that you will have a large volume of automobile traffic as well as delivery trucks and vans. Your plan should address vehicular traffic as a major concern.
2. Noise/Environmental Concerns: Because aircraft noise is a serious concern for those living close to the airport and within approach and departure areas, careful consideration should be given to planning for low impact on the community.

Completed Project

Upon completion of the project, prepare a presentation for a group to be designated by your instructor. You may wish to use drawings to illustrate both overall plans and detailed sections. You may also use a model or mock-up to help illustrate your proposal. Present your plan as if you were making a bid for a new airport facility.

MAKING A STANDARD COLOR CONTROL NEGATIVE

Essential Elements: Common: 2, 6, 8-10
Specific: 3, 7, 11
TAAS Objectives: Language Arts: RC 1-6
WC 1-4

Activity Summary

This activity is intended to provide advanced-level students with an independent study project in which they produce their own standard control negative for color printing. Students will use the Kodak 18% gray scale card, color negative film, a camera, and color darkroom facilities to produce this color printing aid. Using the standard negative will help advanced-level students understand and use the basic principles of of color printing.

Teaching Tips

1. Become familiar with basic color printing procedures before releasing this activity to students.
2. Make an example of the procedures which can be displayed on a bulletin board for students to view.
3. Allow students ample time to complete the activity, as it may take several weeks to finish.
4. Review safety procedures for handling color printing chemicals.

Instructional Strategy

- Use this activity as an independent problem-solving project.
- Have students use the problem-solving model to plan their activities.
- Use periodic brainstorming sessions to monitor progress and answer questions.
- Have students present their efforts in a display of their work.
- Have students complete a short technical paper to summarize their project.

Equipment/Supplies

1. Color darkroom equipment
2. Camera
3. Color negative film
4. Color photographic paper and processing chemistry
5. Kodak 18% gray scale card
6. Exposure meter

Evaluation Key

Instructor evaluation of this activity should be based on student participation in and completion of the project. Students should be able to apply their standard control negative data to a series of color prints. Students should also prepare a display of their work as well as a short technical paper describing their project.

Support Materials

1. *Basic Developing, Printing, Enlarging in Color*, Kodak Publication No. AE-13.
2. *Library of Photography, Color*, Time-Life Books.

MAKING A STANDARD COLOR CONTROL NEGATIVE

Learn how to make a standard color control negative.

Objectives

- To use the Kodak 18% gray scale card to produce an accurate exposure on color negative film
- To use the Kodak 18% gray scale card to help create a standard control negative
- To use the standard control negative to establish starting filter factors and exposures when making color prints from color negatives
- To prepare a short technical paper based on collected data

Vocabulary/Concepts Reinforced

- White light —Daylight or the light from a color enlarger bulb is composed of the three primary colors, **red**, **green**, and **blue**.
- Additive color—When the three primary colors are added together in equal amounts they create white light.
- Subtractive colors—These include **cyan**, **magenta**, and **yellow**, which, when each is added to its complementary color, can absorb all color to produce shades of gray or complete black.
- Color negative film—Contains separate emulsion layers which are sensitive to the three additive primary colors. An image recorded in each of these layers is the complementary or opposite of the adjoining layer.

Equipment/Supplies

- Color darkroom facilities
- Enlarger with set of color filters or internal dichroic filters
- Processing chemistry for producing color prints (Kodak EP-2 processing kit)
- Standard control negative
- Print processing tube or processing trays
- Time and temperature chart
- Color correction viewing filters or color balance chart
- Rubber gloves
- Kodak 18% gray card
- Kodak color negative film (the type you normally shoot)
- Camera

Introduction

This activity is intended to provide advanced-level students with an independent study project in which they produce their own standard control negative for color printing. Students will use the Kodak 18% gray scale card, color negative film, a camera, and color darkroom facilities to produce this color printing aid. Using the standard negative will help advanced-level students understand and use the basic principles of color printing.

Background Information

Within the graphic arts industry one of the most important allied fields is color print processing. The development of point-and-shoot cameras and the ability to process film into prints within an hour has helped to establish an entirely new industry. One-hour photofinishers have opened up in many shopping malls and at convenient

locations in shopping center parking lots across the country. These elements have made color photography relatively inexpensive and accessible to almost everyone.

Automation of film and print processing has made the use of color photography an economical means of both communication and entertainment. Gone are the days of dropping off your exposed color film and waiting a week to see the resulting prints. The development of equipment which can be set up in a relatively small space, be operated by a basic-level technician, and produce high-quality photographic prints in less than one hour has revolutionized photography.

Most untrained photographers have little or no understanding of the color printmaking process. Their only understanding of the process is witnessing the assortment of machines behind the counter at the quick photo finisher. Those photographers, however, who have a basic understanding of the process will appreciate the technology that has made this quick print industry possible.

Advanced-level Communication Graphics students should learn basic color photography. The skills learned through correctly exposing color film and creating color prints from processed negatives will improve the technical level of students. Students will learn the basic characteristics of color as it relates to light and light-sensitive materials.

In order to successfully make color prints from color negatives the student should become familiar with the characteristics of white light and how they are controlled throughout the printmaking process. One method that greatly improves the development of these skills is to produce a standard control negative. The standard control negative is a negative, which can be produced by the student, that contains the best possible characteristics of both exposure and color. This negative will be used to establish a set of beginning exposure settings and color filter factors for subsequent prints.

The standard negative is made by making an exposure, under typical lighting, with the type of film the photographer normally shoots. For example, if the photographer shoots mostly Kodak Kodacolor VR 200 film outdoors under bright sunlight, then the standard negative should be made with that film under those lighting conditions. If, on the other hand, the photographer shoots the same film on studio shots, the standard negative should be made in the studio.

The key to obtaining a good-quality standard negative is to use the Kodak 18% gray scale card in the picture area. This card looks like a piece of gray mounting board but has two very important functions. Because the card is produced to accurately represent 18% gray, or the exact middle gray tone that film exposure is balanced for, very exact exposures can be obtained if the exposure meter reading is taken from the light reflecting off the card. The second function of the card is to serve as a color balancing check to compare the color in a print to the exact color of the card.

The first important function of the card is exposure control. Remember the basic function of the reflected light meter built into your camera. The meter is calibrated to measure the intensity of light reflecting from the scene and balances this intensity to a middle gray tone level. At the extreme ends of the scale are complete white at the brightest end and complete black at the darkest end. Film is designed so that the correct exposure for the film is based on this same middle gray tone. Kodak produces a card, called the 18% gray scale card, that duplicates this middle gray tone. Assuming that a light meter is accurate and the camera is functioning

properly, a reflected meter reading taken from the card will yield a technically perfect exposure.

The second function of the card is its use as a control standard when determining color balance when processing color prints. By including the 18% gray card in a typical scene that is representative of most of the shots taken with a particular film type, a set of beginning filter factors and exposure times can be established for making subsequent prints from negatives exposed under the same conditions. When this method is used, a series of test prints are made until the gray scale tones in the print match the gray scale tone of the original card. Occasionally, very slight differences may occur when a negative was exposed either early in the morning or late in the afternoon.

By combining these two elements into the color printing process, the student photographer will be able to produce consistently good quality prints. Care should be taken, however, to move in close to take the meter reading from the card. Also, try to arrange your standard negative scene such that the size of the card is large enough in the resulting test prints to clearly judge its color against the actual card.

Procedure

1. Begin by loading your camera with the type of color negative film you will normally be using.
2. Ensure that the film speed setting is set correctly.
3. Arrange your scene under the lighting conditions which you will normally use.
4. Have your subject hold the gray scale card somewhere near the center of the scene. Remember that the card will need to take up a sizable area of the scene, so move in relatively close.
5. Make an exposure reading from the card being careful not to cast a shadow on the card or change the quality of the light striking the card.
6. Make two exposures of this scene.
7. Duplicate this procedure in a shaded area and make an additional two exposures.
8. If you plan to do any studio photography, you should also shoot two or three standard negatives under the studio lights.
9. Have the film commercially processed to ensure accuracy in the completed standard negative.
10. In the darkroom create a series of 4" x 5" test prints using your standard negative. Use beginning exposure times and filter factors recommended by your instructor for the equipment and processing materials that you will be using. If you are using Kodak Kodacolor film, start with 50M and 90Y. Make a test print using these filter factors for 10 seconds at *f*5.6, *f*8, *f*11, and *f*16.
11. Determine print exposure time first. Do not attempt to judge for correct color balance until you have clearly established correct exposure time.
12. When you are comfortable with the exposure time, begin to compare the printed gray card area to the actual card. Use the Kodak color comparison chart to determine color correction factors. Remember that there are no shortcuts at this stage and you must follow the print processing steps very carefully. Do not judge wet prints for color balance.
13. As you work with these test prints be sure to record your data in order to avoid duplication. Use a photographic marking pen to label each test print.
14. When you have established the best set of exposure times and filter factors for your standard control negative, record the data on the package of photographic paper you are using. This will establish the beginning exposure settings and

filter factors for all subsequent prints using the same film type and paper. It should be noted that slight variations will sometimes occur between different batches of photographic paper, and you should make a test print using your standard negative to calibrate each new package of paper.

15. Based on the application of this process create a series of enlargements for display. Your instructor will determine the number of prints required for this project.
16. Write a short technical paper to detail the procedures that you used in completing the assignment. It is recommended that you use the problem-solving model as an outline to work through the overall activity, including the technical paper.

Evaluation

1. Evaluation of student performance will be based on participation in the activity and the production of a series of 8" x 10" color prints using the standard control negative to help determine exposure and filter factors.
2. Additionally, your instructor will have you write a short technical paper to explain the procedure and report your technical data for future reference.

STUDIO PHOTOGRAPHY

Essential Elements: Common: 6, 8, 9
Specific: 9, 11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is intended to provide advanced-level students with an independent study activity in which they learn basic studio photography. Students will complete a set of basic lighting problems using electronic flash equipment with umbrellas and reflectors. In the first phase of the activity students will photograph a store mannequin using various lighting techniques. In the second phase they will complete a series of studio portraits using student models. Students will present their mounted and finished work in a schoolwide display. They will also prepare a short technical paper in which they present their technical data and summarize the lighting techniques used.

Teaching Tips

1. Read through the entire activity before releasing to your students.
2. Provide students with independent time in which they can help set up and use a studio with lighting equipment.
3. Discuss the preparation of a technical paper in which the students will summarize their project.

Instructional Strategy

- Use a small group discussion to present the topic to your research and development students.
- This activity should be presented as either a small group or individual independent study activity.
- Demonstrate the use of the studio lighting equipment available to your students.
- Have students prepare a display of their prints for other students to view.

Equipment/Supplies

1. Camera with tripod
2. 100mm or 135mm medium telephoto lens for the type of 35mm camera being used. You may want the students to use a larger format camera if it is available for student use.
3. Studio lighting equipment
4. Flash meter if available
5. Mannequin torso and head
6. Darkroom facilities
7. Photographic film and paper as needed
8. Background paper or drop cloth as available

Evaluation Key

Evaluation of student performance for this activity should be based on student participation and completion of the project. Because this is an independent study activity, arrange periodic meetings in which you can monitor student progress. Students will submit a series of 4" x 5" prints of the mannequin for your evaluation of lighting technique. They will also submit a series of mounted 8" x 10" prints of student models for display. You may also have students write a short technical paper in which they describe the techniques and processes they used.

Support Materials
Photographic magazines, books, etc., for students to view examples of studio portraiture

STUDIO PHOTOGRAPHY

Learn how to use various lighting techniques for studio photography.

Objectives

- To set up and use a basic studio lighting system
- To produce a series of studio portraits using various lighting techniques
- To select the proper camera, lens, film, etc., needed to produce quality studio photographs
- To write a short technical paper related to a specific topic

Vocabulary/Concepts Reinforced

- Power pack—Central unit powering light output through separate flash heads.
- Flash head—Unit containing flash tube and modeling light connected to the power pack by a cable.
- Main light or key light—Primary source of illumination on the front of the subject.
- Fill light—Secondary light on the front of the subject.
- Back light—Separate light used behind the subject to control the tonal gradations of the background or to wash away shadows.
- Hair light—Separate light used to provide highlights and differentiate the hair from the background.
- Rim light—Separate light aimed from behind the subject toward the camera to provide a bright edge of light.
- Gels and diffusion sheets—Plastic sheets in a variety of colors used to change the color or soften the output of a flash head.
- Umbrella—A reflecting device used to soften the point source of an electronic flash tube.
- Watt/seconds—Measure of the electrical storage capacity in a power pack. Actual light output is affected by many other factors, especially flash tube and reflector efficiency.

Equipment/Supplies

- 35mm SLR camera with tripod
- 100mm or 135mm lens
- Studio lighting equipment
- Flash meter
- Mannequin torso and head
- Darkroom facilities for processing film and printing
- Photographic film and paper as necessary
- Background material

Introduction

This activity is intended to provide advanced-level students with an independent study activity in which they learn basic studio photography. Students will complete a set of basic lighting problems using electronic flash equipment with umbrellas and reflectors. In the first phase of the activity students will photograph a store mannequin using various lighting techniques. In the second phase they will complete a series of studio portraits using student models, presenting the mounted and finished work in a schoolwide display. Students will also prepare a short technical paper in which they present the technical data and summarize the lighting techniques used in their projects.

Background Information
Portrait photography has been an important part of the photographic process from its development in the mid-1800s. Early portrait photographers were limited to the use of large cumbersome cameras, available sunlight, and extremely long exposure times. These restrictions greatly limited their results to rather stiff-looking portraits because subjects had to sit through exposures that took three to four minutes. Can you imagine having to sit perfectly still for a three-to four-minute exposure? It would certainly be difficult to look relaxed.

Although modern photography has evolved into a highly technical process, many of the standard lighting techniques used by today's studio photographers are based on the lighting characteristics used by the early photographers. The early photographers depended on the sunlight that passed through the windows and skylights of their studios. The quality of light was most often soft yet directional. These early studio photographers studied the master portrait painters like Rembrandt to achieve this natural and simple technique. As you view many of the traditional studio portraits taken today, you will see a remarkable resemblance to these old paintings.

Procedure
In order to better understand the use of basic studio lighting it is appropriate to work through a sequence of basic lighting problems. The first phase of this activity emphasizes several basic lighting techniques. In phase two of the activity students will produce a series of prints in which they apply these techniques to live models.

Phase I—Basic Lighting Techniques
For the first phase of the activity you will need a camera with film, one flash head, one umbrella, a reflector, and a mannequin for your subject.

Begin by setting up the mannequin as you would a real person. The head of the mannequin is all that you will be photographing during this exercise, so place the head at a normal height. Turn off the room lights and turn on one of the flash head modeling lights. Stand at the camera position and have an assistant stand at the camera and point the flash head toward the subject. Keeping the flash head pointed at the subject, have your assistant slowly move around the subject. Notice how the direction of the light affects the shadows on the face of your subject. Pay particular attention to the nose shadow. Have your assistant move the light high overhead so that it shines down on the subject, as well as low shining up towards the subject. As you can see, many dramatic effects can be accomplished with just one simple light.

Now photograph the mannequin using the following lighting setups.

1. One-Light Portrait with Umbrella Reflector—"A"
   Set up the flash head with its umbrella reflector as shown in figure 1. Place the flash head and umbrella so that it is above and 45 degrees to the subject. Use the flash meter to check your exposure and take a couple of shots with this setup.

2. One-Light Portrait with Umbrella Reflector—"B"
   This is the same setup as used above except the flash is aimed at the subject through the umbrella (fig. 2). Although the amount of light hitting the subject is somewhat more diffused, this method does provide for a little more directional light. Use the flash meter to check the exposure and make a note of what

difference there was between the first setup and this one. Again, make a couple of exposures of this combination.

3. One-Light Portrait with Umbrella Reflector and Flat Reflector
   Set up this portrait with the umbrella and flash head on the right side of the camera above and 45 degrees to the subject (fig. 3). Use a large sheet of white posterboard to the left of the subject, which serves to bounce some light back into the subject. This is a very good setup for making professional quality portraits. Check the exposure again and make a couple of exposures.

4. Two-Light Portrait with Umbrellas and Flat Reflector
   In this setup we will add a second flash head and umbrella reflector. We will also use the flat reflector as in the previous example. Set the equipment as in figure 4. Notice the spacing of the two umbrella reflectors. The closest one is the main light and the one next to the camera is the fill light. Use the flat reflector to help fill some of the shadow areas on the right side of the subject. Again check your flash meter and make a couple of exposures of this setup.

5. Three-Light Portrait with Umbrellas and Background Light
   Set up the equipment as in figure 5. Notice how the third flash head is pointed toward the background. This technique helps to provide a highlight behind the subject and improves the overall balance of the lighting. Check your flash meter to verify exposure and shoot a couple of pictures using this lighting combination.

Process your film and make a set of 4" x 5" prints to illustrate each of the techniques above. Your instructor may want you to provide specific technical data for each print. Your instructor will sit down with you and critique your shots.

Phase II—Shooting Live Models

Now that you know how to set up the studio lighting equipment, you are ready to begin shooting live models. In the second phase of this activity you are to apply the lighting methods used on the mannequin to live models. Select a model who will be willing to sit through a shooting session and have his/her photographs displayed.

The key to success at this phase is to think through each step of the process and not be overwhelmed with photographing a real model. Probably the most difficult thing for student photographers to do is fill up the viewfinder of the camera. With that in mind it is advisable to use a tripod to support the camera. When you look through the viewfinder, try to imagine that you are looking at the finished print. Use the camera mounted vertically so the film format fits the shape of the subject.

Arrange to photograph a couple of different student models for this activity. Set up the studio lighting equipment and photograph your models using the lighting techniques that you have tried. Also experiment with lighting variations and try some lighting techniques to create special effects. Experiment and have fun. When you have completed your shooting session, process the film and make a contact sheet of your negatives. Select at least five negatives that will produce good quality enlargements, and print 8" x 10" enlargements of each. After the prints have been spotted, mount them on 11" x 14" mounting boards for display.

Upon completion of the prints each student should prepare a two-page technical paper in which he/she describes the lighting technique used for each of the prints in his/her presentation.

Evaluation

Teacher evaluation of this activity will be based on student participation in and completion of the project. There are two phases to the activity which students must complete. The first phase is a self-paced studio lighting lesson in which students produce a series of 4" x 5" prints to illustrate the use of the various lights available to them. The second phase is to complete a series of studio portraits using students as models. These prints will be mounted and displayed for other students to view. Additionally, a short technical paper will be required to summarize the project. Specific evaluation criteria will be discussed by your instructor.

ONE-LIGHT PORTRAIT WITH UMBRELLA REFLECTOR-"A"

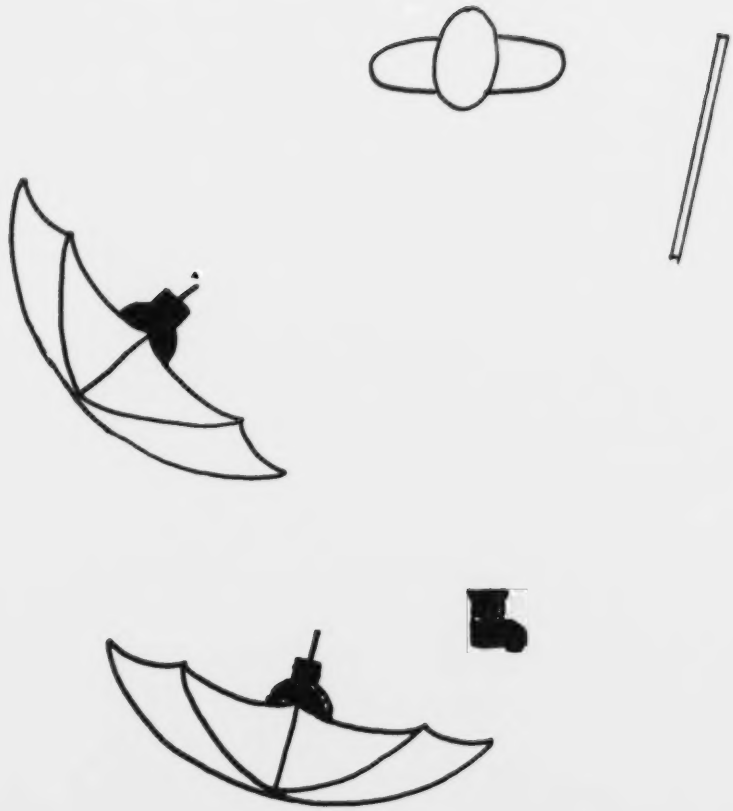
Figure 1

ONE-LIGHT PORTRAIT WITH UMBRELLA REFLECTOR - "B"

Figure 2

ONE-LIGHT PORTRAIT WITH UMBRELLA AND FLAT REFLECTOR

Figure 3



TWO-LIGHT PORTRAIT WITH UMBRELLAS AND FLAT REFLECTOR

Figure 4

Figure 5

VIDEO PRODUCTION

Essential Elements: Common: 1, 2, 4, 7, 9A, 10
Specific: 1-9
TAAS Objectives: Language Arts: RC 1-6
WC 1-4

Activity Summary

This lesson is designed to allow the student to learn some basic tips on producing a video program from the creative aspect. After covering basic information on camera positions and angles, the use of sound, production tips, storyboarding, transitional devices, etc., the student will produce, individually or in groups, a short video program. Emphasis will be on using information from the lessons, specifically, camera angles and positions and transitional devices.

Teaching Tips

1. The teacher might want to show the students some examples of the films discussed in the lessons or some other classic, such as *Citizen Kane* or *Casablanca*, before the unit begins to give the students some ideas on cinematography.
2. In keeping with the idea of Research and Development, these lessons would be part of the basic research. All of these lessons are designed to be done independently, with occasional monitoring by the instructor.
3. The time required will depend on the amount of work done by the student outside of class. The amount of equipment available would also be a factor.
4. Stress to the students that they prepare some type of storyboard or script before they actually begin production. Many times the students don't do enough planning before they actually begin production.

Instructional Strategy

- In the belief that the Research and Development class is an independent study class, the teacher should provide initial direction for the students, but then the students determine the proper procedures in producing a program.
- In an independent study setting, it is extremely important to constantly monitor the students to ensure that work is progressing smoothly.
- The students should be expected to come to the teacher with a list of the equipment and materials necessary for the production, rather than the teacher just providing it.
- The purpose of this research project is to produce a video program, not necessarily just to learn the operation of video equipment. Help the students keep this in mind.
- The lessons are set up in such a way that the students can read them at their own pace, but they should finish at least one lesson (including answering the questions at the end) each time they work on it. The questions at the end of each lesson will be due at the end of the video unit in the form of a notebook containing all of the work done in the unit.
- As you may notice, the term *film* is used throughout this module. It should be stressed to the students that they are not producing a film. They are working with videotape, which is a magnetic recording material. It is a lot less expensive to use videotape rather than film, so we use it to teach this unit. Even though the term *film* is used quite often, they need to keep in mind that they are really working with videotape.

Equipment/Supplies

1. Video equipment
   - video camera
   - VCR
   - television
   - blank videotapes
2. Optional video equipment
   - second VCR/editing equipment
   - tape player (dubbing sound)
   - special effects generator/titler
3. Storyboard blanks
4. Magazines as picture sources

Evaluation Key

This module can be separated into four or five grades. The questions at the end of the five lessons total 200 points. A storyboard or script would be another grade, and the final program would be another one or two grades. In R&D, grades are based on the students' attempt at a project and their written record of that attempt, rather than the project itself, so the instructor must decide how much emphasis to place on the written report and how much to place on the video program.

Support Materials

1. Videocassettes of film classics as examples
2. Instruction manuals for the equipment

VIDEO PRODUCTION

Produce a video program encompassing a variety of transitional devices, camera movements, and camera angles.

Objectives

- To introduce the student to several key figures in the development of motion pictures
- To produce a reference notebook containing the answers to each lesson, examples of camera positions, and a storyboard/script for a video program
- To produce a short video program or commercial using at least two examples of transitional devices, four examples of camera positions, and three examples of camera movement

Vocabulary/Concepts Reinforced

- Eadweard Muybridge
- George Melies
- D.W. Griffith
- Persistence of vision
- Transitional devices (cut, dissolve, fast pan, wipe, fade)
- Shot
- Setup
- Camera positions (extreme long shot, long shot, medium long shot, medium shot, medium close-up, close-up, extreme close-up, over-the-shoulder shot)
- Camera movement (pan, tilt, dolly, tracking, boom, high/low angle, zoom)
- Framing
- Editing
- Sequence
- Intercutting
- Continuity
- Montage
- Documentary, experimental, and narrative fiction films
- Storyboard
- Counterpoint
- Production skills

Equipment/Supplies

- Video equipment
  - video camera
  - VCR
  - television
  - blank videotapes
- Optional video equipment
  - second VCR/editing equipment
  - tape player (dubbing sound)
  - special effects generator/titler
- Storyboard blanks
- Magazines as picture sources

Video Production
Lesson 1

The first photographs that record movement in fragments were taken by Eadweard Muybridge in 1872 in order to prove that a horse lifts all four feet from the ground at once when galloping. Muybridge took these pictures by setting up a row of still cameras with strings attached to their shutter triggers so that the horse would snap picture after picture of itself as it galloped by. As Muybridge had hoped, some of the developed pictures showed the horse with all four hoofs off the turf at one time.

If Muybridge had made positive images on transparent film from each photographic negative and then glued these together into a strip, the result would have been the first motion picture. Although it would presumably have been jerky, these fragments of motion could have given the viewer an illusion of a galloping horse.

Persistence of vision is the basic principle which allows us to perceive a sequence of fragments as a smoothly moving whole. The nerves of the eye retain any fixed image for a brief moment after the picture itself is gone. If another, slightly different image is quickly presented, the eye will blend the two together, seeing the differences as the illusion of utterly lifelike movement.

It is the **fragmentation of movement** that gives films the potential of art, for a film editor can almost literally hold motion in her/his hands, composing with it as a musician composes with sounds or a writer with words.

Audiences were attracted to the earliest motion pictures by the sheer novelty of seeing pictures move, and early films were simply recordings of subjects in motion—running horses, speeding railroad trains, crowds of people. Continuing curiosity about motion pictures proved that films could make money, so early producers quickly became accomplished showmen, setting up incidents to photograph, such as the head-on collision of two old locomotives.

Simple recordings of motion and stunts soon led the way for tricks with the camera itself. Georges Melies, a French theater owner who had guessed the entertainment value of motion pictures, discovered a novel capability of the camera. He found that if he stopped the camera while filming a subject, but did not move the camera; and if, while the camera was stopped, the subject moved out of the frame; that if he began to film again, the resulting footage would show the subject to have disappeared in a blink, because the camera did not photograph it leaving the frame.

Melies quickly took advantage of this trick, and beginning in 1896 he developed complicated films in which objects appeared and disappeared magically. One of his most amusing picture ideas concerns a man who approaches a coatrack wearing an overcoat. He removes his coat and hangs it on the rack, but suddenly it reappears on his back. No matter how he tries, he cannot remove his coat permanently. Finally, he falls to the floor in a fit of exasperation.

Melies also filmed actual scenes in a theater. He filmed *Cinderella* in twenty separate scenes, joining these to produce the first story on film. He originated most of the transitional devices filmmakers use today for joining or bridging two scenes. These are:

1. **Cut**—a direct splicing of one shot to another which changes the image abruptly. The cut, the most commonly used method for joining shots,

emphasizes the fragmenting capability of the camera. When many cuts follow one another, the entire scene seems made of bits and pieces.

2. **Dissolve**—the gradual intermingling of one image with another so that the first slowly fades out as the second fades in, replacing the first image more and more strongly. Slow dissolves create a feeling of vagueness, as if the things seen on the screen are somehow connected. The dissolve once was commonplace for indicating memories. Nowadays, dissolves are used more frequently to suggest the flow of life, for they do not fragment scenes harshly, as cuts do.
3. **Fast pan**—a blur, usually created by rather quickly rotating the camera in a circle. A swish pan suggests a sudden, emphatic change of locale; hence, it is useful as a transition in action-adventure films.
4. **Wipe**—a new image appears, usually at one side of the frame, and seems to push the old image out of the frame. The wipe usually indicates a strongly related change in locale or time—the equivalent of saying, "While A is happening, B is also taking place."
5. **Fade**—the screen darkens until it is black (fade-out) and then lightens as the new image appears (fade-in). The fade creates a definite sense that one action or idea is complete and another will begin. Fades are slow and give an audience time to think or adjust to change.

Over the years audiences have accepted these transitional devices as representing specific things. But a filmmaker is not bound by this "understanding." A straight cut tends to represent no change in time, but possibly a change in space. A dissolve is a passage of time indicated or a change in space. Fades represent a longer period of time than a dissolve and if a change of space occurs, then a passage of time is also understood. If the scene goes out of focus and then back into focus, the audience associates it with a memory flashback. Wipes are a change in time and space, while a montage (e.g., spinning headlines, pages of a calendar tearing off) is a passage of time.

Lesson 1 Exercises

Answer these questions on your own sheet of paper. Your answers must contain the restated question. For example, if the question reads, "What is persistence of vision?" your answer should begin, "Persistence of vision is..."

1. What is persistence of vision? (5 points)
2. What was the trick that Georges Melies discovered? (5 points)
3. What are two television programs or movies that have used Melies' trick? (10 points)
4. Use your imagination and come up with two short scenes that might use a cut as a transitional device. Write out these two scenes. Would a dissolve or wipe work in the same place? Why or why not? (10 points)

Video Production

Lesson 2

The basic unit of any motion picture is the **shot**. It is a single, uninterrupted run of the motion picture camera from start to stop. For example, if we wished to show a woman answering a door, we might accomplish our purpose in just one shot taken from one **setup** (camera position) across the room. Our shot of some 30 seconds would begin with a view of the woman talking on the phone. A doorbell rings, and we watch as the woman rises, walks to the door, and opens it. Because the camera did not stop, this would be one shot.

Movement within the scene by something in the scene will attract the viewer's eye. The viewer will watch whatever moves during the entire shot. But this movement by something in the scene can have a number of possible directions. The object can move left or right, into or out of the frame, up or down, diagonally, in a curve, or in a combination of the other movements.

The quality of a subject's movement—its direction, intensity, speed, and duration—contributes directly to the emotional content of the shot. It can be violent or tranquil, fast or slow, smooth or jerky, and as such it reflects the theme of the film.

When nothing moves in a frame, another kind of movement can occur. The viewer's eye, freed from the need to follow moving figures or objects, can roam, examining the composition of the static picture. Certain compositions seem to have different psychological effects on a viewer. Circles and curves suggest harmony and happiness. Diagonals suggest action and conflict. Horizontals suggest tranquility and peace, while verticals suggest majesty, awe, and spirituality.

It was Edwin S. Porter who first decided to film a story constructed from several scenes by moving his camera between the scenes in order to use the best angle from which to view the action. The first close-up in motion pictures appears at the end of his film *The Great Train Robbery* (1903) when a bandit fires his gun directly at the viewer. When the film was first seen, this shot invariably caused early audiences to come close to panic.

Porter had discovered one of the motion picture's major strengths. The audience "moves" with the camera. This camera mobility allows a director to move in close to show a significant detail or expression, or to move away to cover an entire action.

Following are basic terms used to indicate this camera-to-subject relationship:

1. **Extreme long shot (ELS)**—Used to depict vast areas and to orient the viewer. Also known as **establishing long shot**.
2. **Long shot (LS)**—Used to depict the entire area of the action.
3. **Medium long shot (MLS)**—Used to depict a full-length view of an actor or of the action, but not of the full set.
4. **Medium shot (MS)**—Used to depict an actor above the knees or below the waist to the head. It may involve several actors as stated, but it is able to reveal facial expressions.
5. **Medium close-up (MCU)**—Used to depict an actor midway between the waist and shoulders to above the head.
6. **Close-up (CU)**—Used to depict an actor from just below the shoulders to above the head.
7. **Extreme close-up (ECU)**—Used to depict the actor's head or some closer portion of the actor's face or body.
8. **Over-the-shoulder shot (OSS)**—Used to depict the back of the neck and shoulder of one actor on one side of the screen while another actor is open to the camera.

Camera mobility, as directors soon learned, allows the filmmaker to stop the camera and then change its distance and angle in relation to the subject so that the audience may see more. Audiences used to watching plays in a theater were startled to see the background jump back and forth in a film. Soon directors discovered that they

could also follow action by moving the camera while it was running. By this camera movement, the entire background appeared to move continuously through the frame without jumping about. Following are some methods for moving the camera:

1. **Pan**—when the camera moves on its horizontal axis
2. **Tilt**—when the camera moves on its vertical axis
3. **Dolly shot**—when the camera moves into or away from a subject. Should be described as **dolly in or dolly out.**
4. **Tracking shot**—when the camera moves on tracks with a moving subject.
5. **Boom shot**—when the camera moves upwards or downwards. Can be **boom up** or **down.**
6. **Low angle shot**—when the camera is placed below eye level and tilted up.
7. **High angle shot**—when the camera is placed above eye level and tilted down.
8. **Zoom**—used to bring the image from wide-angle to telephoto or vice versa.

Whatever attitude the camera takes toward the subject—whether of admiration or disdain, indifference or sympathy—the viewer takes on the same attitude. And the camera's attitude is shown by its distance from the subject and the angle at which it looks at the subject. One of the best sources of dynamic pictorial angles is the comics. The artists designing comics have often sought the best position from which to state the action in a panel. Consequently, the angles they use are often highly original and highly expressive.

Besides dealing with camera placement and camera movement, the filmmaker must also deal with composition, just as a photographer does. The composition is very important to the total feeling which the film possesses.

Framing is one tool of composition. The rectangular or square border that frames a film is a great asset to the filmmaker, because it allows her/him to isolate figures and places and attract attention to them. The effect of a frame will always be to set apart and distinguish what is inside. On a regular-sized screen, the framing of the screen can concentrate on ordinary things and thereby give them added beauty: the glitter of water in a creek, a flash of sun through branches, a buoyant face.

Another kind of framing that the film uses is called interior framing. This is the conscious effort of the filmmaker to set up his/her shots so that the characters and action are framed within the total picture. This conscious device of framing can make very effective statements about the situation in the film.

Lighting is also very important to a film. There are no rigid rules about the use of lighting—simply the general demand that lighting be used for more than realism, that it be highly expressive of what the filmmaker is trying to communicate. The lighting should fit the mood of the scene.

Lesson 2 Exercises

Answer these questions on your own sheet of paper. Your answers must contain the restated question. For example, if the question reads, "What is persistence of vision?" your answer should begin, "Persistence of vision is..."

1. What is the shot? (3 points)
2. Describe two ways (action verbs) that a man could enter a room. What would each of these actions imply to the viewer? (10 points)
3. What composition suggests action and conflict? (5 points)
4. What composition suggests tranquility and peace? (5 points)
5. Using either photographs from magazines or comic strips, find one example of each of the camera-to-subject positions. Attach these to your paper and identify the position shown. (24 points total/3 each)
6. Using the eight pictures from the previous question, describe what you think the photographer or artist was trying to say about the subject with the choice of camera position and angle. (16 points total/2 each)

Video Production
Lesson 3

During editing, a film is put into its final form, exactly as it will appear on the screen. All the other processes lead up to the editing, of course—the writing of a shooting script, the selection of shots, the improvised shooting, and much more.

Editing involves taking sections of film or tape and either physically attaching them together or using machines to transpose them onto another videotape in the order you want them. The film editor controls the movement between shots and establishes the sequences which make up the film. It is, however, the original choice of shots, their length and arrangement, which constitutes the art of editing, and consequently the art of filmmaking. For example, if an edited film contains 600 shots, all of which are one second longer than necessary, the entire film contains ten full minutes of tedium.

A **sequence** is a series of shots grouped together for a purpose. The individual shots fragment reality; the sequence resynthesizes these fragments into purposeful wholes. A sequence in a film is roughly comparable to a paragraph in writing. For example, return to the problem of showing a woman talking on the phone and hearing a knock on the door. This short action could be presented in a sequence of six shots (see fig. 1):

Shot 1 would be a LS for three seconds of a woman sitting and talking on the phone.
Shot 2 would be a MCU for five seconds of the woman looking to her left.
Shot 3 would be a MS for three seconds of the door.
Shot 4 would be a MS for three seconds. The camera would tilt up as the woman rises and goes toward the door, walking out of the frame to the left.
Shot 5 would be a CU for one second of her hand on the doorknob.
Shot 6 would be a MS for three seconds of the woman opening the door.

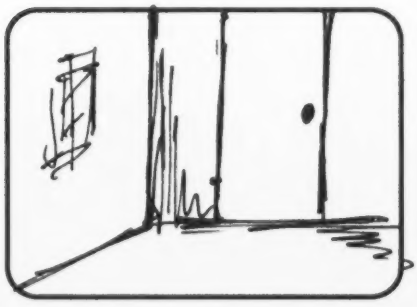
This method of showing the action has several advantages over using the single shot that was discussed in Lesson 2:

1. It is visually more interesting and more "filmic" to move closer to and farther away from the subject and from shot to shot.
2. The total screen time is reduced from about thirty to eighteen seconds, eliminating an eight-second walk across the room. An audience will accept this economy and the elimination of about four seconds of other unnecessary action.
3. The filmmaker can control the audience's attention, gaining impact from his selection of details. For example, if he should wish to foreshadow bad news, he can ask the actress to frown as she looks toward the door. If he is

STORYBOARD

1. _____

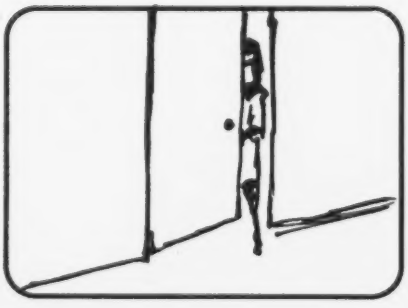
2. _____



3. _____

4. _____

5. _____



6. _____

Figure 1

using only one long shot to cover the action, the actress' frown might be difficult to see.

4. Perhaps most important, the filmmaker can later edit the footage he has shot, adding or deleting shots or parts of shots to vary their length and achieve visual rhythms that suggest the mood of the story, in much the same way that music uses rhythms to achieve an effect.

Real time can also be distorted by controlling the relationship between the close-up and the whole action of the film. Time can be compressed by eliminating unnecessary action; or it can be expanded by making some actions in the sequence overlap or repeat. Actions which might have taken place at the same time in reality can be treated as separate details, lengthening the film time.

Any discussion of editing would be incomplete without mention of the American director D.W. Griffith, who is credited by film scholars with developing editing as we know it today. Griffith was the first filmmaker to:

(1) move the camera closer to an actor so that the audience could see the action;
(2) use the close-up for dramatic emphasis;
(3) cut from one scene to another before the first was finished;
(4) discover the shot as the unit of editing and use it as the basis for communicating on film;
(5) use lighting (backlight and firelight) to enhance dramatic effect;
(6) encourage actors to perform naturally; and
(7) free film from being an exact representation by shortening or lengthening a shot to achieve dramatic effect.

These innovations mark Griffith as one of the world's great film directors. It has been said that no new editing technique has been devised since Griffith developed those listed above in the years between 1908 and 1931.

One of Griffith's most interesting techniques is called **intercutting**. In its very simplest form, intercutting shows two action lines developing simultaneously. This means that we see two different scenes, occurring at the same time, by cutting back and forth from one to the other.

In the narrative film, in which one action or incident follows another in a kind of line or sequence, some attention must be given to **continuity**—that is, the logic and consistency of this line. For example, if a filmmaker has shown a character leaving a room to run an errand, and then we see the character immediately thereafter in the room without watching him or her return, we may be puzzled at this break in story continuity. Continuity of setting is broken when we see objects in the scene which do not fit, such as tire tracks or distant skyscrapers as the ancient Egyptians trek across the desert.

Note that intentionally breaking continuity can be an effective device for an artist. For example, in *An Occurrence at Owl Creek Bridge,* a running man is shown moving from right to left through the forest. Then, without showing a change in his direction, he is shown running from left to right and toward the camera; then, again from right to left. Directional continuity was purposely broken to disorient the audience, making it feel as the runner feels lost and bewildered.

The last editing technique is called **montage**, which means a mounting or a placing together. It is the principle which allows a film to relate or connect shots simply because they are projected on the screen one after another. Montage relies on the tendency of the mind to see as connected film shots that follow one another on the screen. If, for example, an audience first sees a shot of a child crying and then a shot of a bomb exploding, it connects the two, both as an event and as an idea (the inhumanity of war).

Russian directors of the 1920s also discovered that they could intensify emotions through the structure of a montage. The Russian director, Sergei Eisenstein, used a rhythmically climactic montage to build an intense feeling of horror as he showed the slaughter of peasants in the Odessa steps sequence in his film *Potemkin*. The six-minute sequence includes hundreds of shots, many of them only a fraction of a second long. Shots are repeated and overlapped for tragic emphasis. A baby carriage slowly falls down the steps, shown from one angle, reshown from a different angle, then shown from above, and then repeating the cycle again. Each shot is only one to three seconds in length. The film *The Untouchables* by Brian DePalma uses this same technique.

Lesson 3 Exercises
Answer these questions on your own sheet of paper. Your answers must contain the restated question. For example, if the question reads, "What is persistence of vision?" your answer should begin, "Persistence of vision is..."

1. What is a sequence? (5 points)
2. What were D.W. Griffith's seven contributions to film? (21 points total/3 each)
3. What is intercutting? (5 points)
4. What is story continuity? (5 points)
5. What is continuity of setting? What might be a reason for breaking continuity? (10 points)
6. On what does the montage rely? (5 points)

Video Production
Lesson 4
Any filmmaking venture, no matter what type of film it is, involves basically three stages: preproduction, production and postproduction. Generally, preproduction includes the creation of the film script and the necessary planning that goes into preparing the script for shooting. The production stage involves the actual shooting of the film. The third stage, postproduction, includes the editing and the preparation of the sound track and titles. Even though the three stages are separated here, you should always think about them together. Your script writing should be done with the production limitations (what can you do or not do with the camera?) in mind. And when you tape your scenes you should do so keeping in mind what it will take to edit these scenes together later.

Films can usually be classified into three main types: documentaries, experimental, and narrative fiction films. While films can often overlap into two or all three of these types, it is important for you to decide exactly what type of film you plan to produce.

Documentaries are films about "real" events, but only in the sense that you are able to convince the audience that what they are seeing is real. It is the illusion of reality that is most important. Many times documentary films are presented so that the audience feels that they are seeing a real event, but through the filmmaker's

eyes. Documentaries can be films of reenacted events, they can take the form of investigative studies, or they can be filmed as the event is actually taking place. Sometimes films of other types can include a documentary approach in parts of the film.

Experimental films are usually a personal expression of the filmmaker. The filmmaker can challenge the viewer to accept his or her point of view or vision of reality. Many experimental films rely heavily on symbolism to put across a message to the viewer. Experimental films can break the rules of film narrative and violate principles of editing, screen direction, and camera technique. But it is important to know the rules before you can break them.

The vast majority of films are **narrative fiction**. These are films everyone can relate to. These could include all of the popular genre films such as westerns, gangster films, spy films, or comedies. This type of film is intended for entertainment or as an escape from reality.

There are several writing stages through which a film will go in the preproduction stage. These can consist of the original idea, the synopsis, the treatment, the action and dialogue script, the writer's script, and the director's shooting script or production script.

The original idea is the concept behind the film. It is usually nothing more than an idea that a writer or producer has for a film. It is an informal step, because it represents only the idea. The synopsis or treatment will start to turn this idea into something workable. Sources for ideas can come from one's own experiences, the experience of a friend, a newspaper story, an event or story on television or radio news, a short story, novel, or play, or a song or poem. There are advantages and disadvantages with each.

Keep in mind that action and movement are much easier to communicate in film than complex or abstract ideas. For a first-time effort, it may be easier to keep ideas as simple as possible. Some other suggestions: Be careful of films which depend on a twist or surprise ending. Your entire film ends up relying on that one scene. Also consider what type of actors you will have available for your production. Don't put in a scene that requires a practiced performer if you don't have one available. With film it is more important to look natural than it is to perform theatrically. Also keep in mind what resources you will have available for props or settings. Don't put in something that you will have difficulty finding or using.

For documentary films it is often helpful to have an idea with a natural beginning, middle, and end. This is often much easier to translate into a film. If a natural structure like this does not exist, then many times you can create a structure around your film such as the beginning and ending of a day or opening and closing the film with the same shot or location.

A synopsis and a treatment are very similar, but the first formal step in preproduction is the preparation of the film treatment. A treatment serves the following functions:

1. It can communicate in writing the main ideas, events, and characters in the film to anyone who reads it.
2. It will help the filmmaker foresee any problems in securing locations and actors.

3. It will help in the organization of the sequence of events in the film, so that writing the script is made easier.

The treatment is a chronological description of all of the action of the film. It should contain all scenes, all action and events, all locations, all characters with character descriptions, the type of sound to be used (dialogue, music, voice-over), and any foreseen problems. It should not include dialogue or word-by-word descriptions of narration. It should also not include any special effects. A treatment should be concise and to the point. For a short film (3-5 minutes), the treatment does not need to be longer than ½ to ¾ of a page.

The next step in the preproduction stage is the preparation of the film script. This can be an action and dialogue script, the writer's shooting script, the director's shooting script, or the production script. Each one serves a different purpose. An action and dialogue script is usually not necessary for short, nonlip-sync films.

The writer's shooting script is a very elaborate delineation of all shots, locations, characters, action, sound, and technical details of the film. This script serves a variety of functions:

1. The script is a breakdown of all shots in the film.
2. It divides the film into separate locations so that they can be scouted.
3. The script includes all camera placements and movements and all special effects.
4. The script can be a guide in determining the exact length of the film.
5. The script provides a breakdown for the actors as to which shots and scenes they will appear in.
6. The script provides a reference for the breakdown of shots and scenes into a shooting order.

The director's shooting script is usually an elaboration of the writer's shooting script. The writer's shooting script can be developed into a director's script by using notes and diagrams. The notes should contain exact information as to the execution of each shot and should include character placement, movement and gesture, as well as camera placement or movement. The diagrams can be bird's-eye views of character and camera positions. The production script is based on a thorough scouting of all locations, the choice of actors who will play the various roles, and the equipment to be used for the shooting of the film.

A very common approach to script preparation is called **storyboarding**. Cartoons in a newspaper are very simple examples of storyboards. In this process every scene is broken down into the basic action and placement of subjects and camera. Then very rough sketches are made which show exactly what the camera is going to see and for how long it is going to see it. Many of today's movies, especially where special effects are concerned, used storyboarding to help put the movie together. Storyboards are an excellent means of previsualizing exactly what you want the scene to look like.

After the shooting scripts are prepared, the scripts are broken down into the different scenes so that the shooting schedule can be planned. Most films are not filmed in the same order as they are written. If the script calls for the same set to be used more than once in a film, it might make more sense to film all of those scenes at one time. The same holds true when you are dealing with props or locations to

which you have limited access. All of these circumstances may require you to film your scenes out of order.

If this method is used, the planning and scheduling of the scenes is very important. You don't want to start editing and suddenly realize that you have forgotten to shoot a scene. A typical shooting schedule might look like this:

Production: When We Got Old
Dates: October 15-27 (depending on weather)

Monday 15th	*Shot #'s*	*Crew*	*Cast*
AM & PM	2-10	animator and asst.	none
Tuesday 16th			
AM ext hotel	1,13,12	full shooting crew	Warren, Marie
PM int hotel	14,17,16,	" " "	manager, hotel staff
	18,20,22	" " "	Warren, Marie, manager

It is also advisable to prepare a prop list, showing exactly what props are needed for what scenes and when these props will be needed. The same holds true for an equipment list. All of this preproduction is essential to insure that the actual filming is as smooth and efficient as possible. You don't want to waste your time and everyone else's because you did not think about what you were going to do.

Lesson 4 Exercises
Answer these questions on your own sheet of paper. Your answers must contain the restated question. For example, if the question reads, "What is persistence of vision?" your answer should begin, "Persistence of vision is . . ."

1. What are the differences between the three main types of films? (15 points)
2. What purpose does the treatment serve? (5 points)
3. What is the purpose of the writer's shooting script? (5 points)
4. What is storyboarding? (5 points)

Video Production
Lesson 5
Today's filmmakers tend to rely less on dialogue than on other kinds of sound to tell their story. For example, *2001: A Space Odyssey* is three hours long but has only forty minutes of dialogue. In one outstanding sequence, a spaceship moves gracefully toward the moon base accompanied by the lilting melody of a Strauss waltz, thus combining image and music in an artistic whole.

In general, sound and subject should work together; music or sound effects should reinforce visual mood, action, or theme. Typical examples are the swelling romantic or epic theme, chase music, and the use of a muffled heartbeat to create suspense.

At times sound and image operate in counterpoint; that is, they produce an ironic effect through contrast. A painful use of this technique appeared in *The Victors* when the carol "Silent Night" is heard as the hero is being executed by a firing squad on Christmas Day. A somewhat lighter approach appears in *Dr. Strangelove*. As the hydrogen bomb which will start World War III disappears through the mists and the mushroom cloud ripples upward into the stratosphere, the

audience hears the saccharine strains of "We'll Meet Again." Such ironic contrasts rarely fail to shock or to extract groans of appreciation from audiences.

There are basically four kinds of sound in films: natural dialogue (when actors speak), commentary, music, and sound effects. All of these forms of sound can contribute to the total language of film—or (and this is the most frequent use) they can distract from it. Indeed, the temptation with sound is to use it to distract—to make sure the message gets across to the viewer no matter what. Unfortunately, more often than not, the message is stated directly, either through a narrator, the pitch of violins as lovers kiss, or the unneeded statement by an actor, "I feel sick," when his face could have expressed the same thing.

The key is that sound in a film must fit within the total film language and not attempt to be a language all its own. A film that uses dialogue only when it has to, and which uses gestures, action, and facial expressions as much as it can, will seem better made than the film that uses dialogue as a crutch.

The film has within it the power to educate our ears. It can enable us to hear, just as it enables us to see, by its sensitive, precise use of sounds—words, music, or natural sounds. A song, the crash of a hound running through the underbrush, a stone falling to the ground—simple sounds like these can be significant and meaningful, as they almost never are in real life. And music—heard so often without really being heard—can become more beautiful, more meaningful than ever before—simply by its relationship to the visual language of the film.

It is when sound in film enables us to hear better that it is being used within to its fullest extent as a meaningful aspect of film language. For here we can be sure that the filmmaker is working with real sensitivity, and that she or he is attempting to integrate the sound within the total film experience.

The thing to keep in mind is that film is really three languages: visual, moving, and audible.

Lesson 5 Exercises

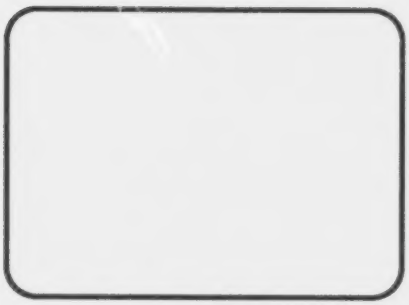
Answer these questions on your own sheet of paper. Your answers must contain the restated question. For example, if the question reads, "What is persistence of vision?" your answer should begin, "Persistence of vision is . . ."

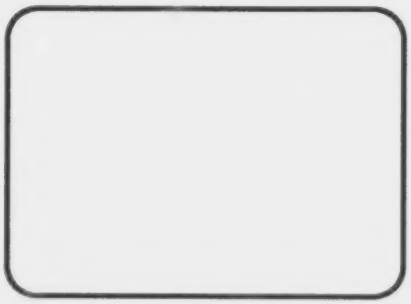
1. What is counterpoint? (5 points)
2. Can you think of another example, besides the ones listed, of counterpoint in a television show or movie? (5 points)
3. What are the four kinds of sound you find in a film? (16 points total/4 each)

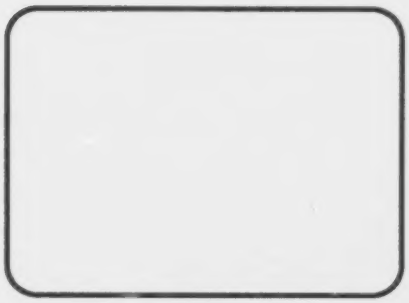
Now that the basic research has been completed, the student(s) should develop some type of film using the information covered in the five lessons. Either a storyboard or director's script should be prepared, based on the requirements of the instructor.

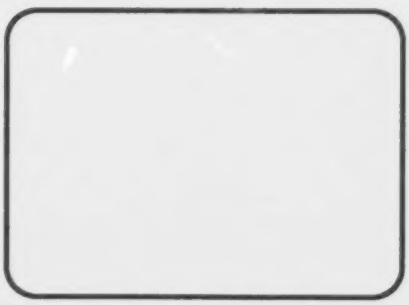
The completed film should display two examples of transitional devices, four different camera positions, and three examples of camera movement. The subject matter of the film is up to the student(s), with instructor approval.

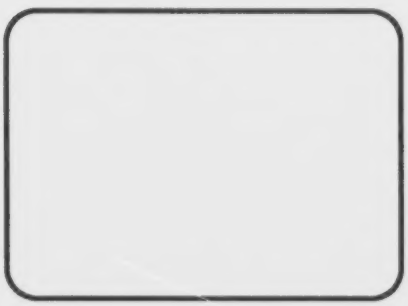
STORYBOARD

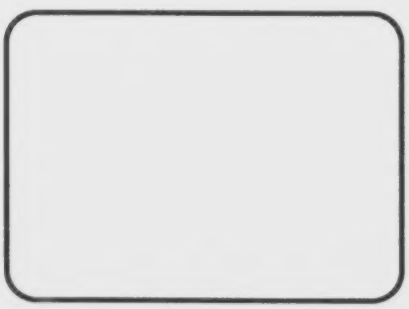












NEWSLETTER

Essential Elements: Common: 1, 2, 4, 7, 9A, 10
Specific: 1-9

TAAS Objectives: Language Arts: RC 1-6
WC 1-7
Mathematics: C 4

Activity Summary

Working individually or in small groups, students will design, write, produce, and distribute a 2-4 page newsletter for one of the student organizations at the school.

Teaching Tips

1. While access to computers is not a necessity for this activity, it would help. Journalism programs or computer science/math programs might have a computer that the students could use when the time comes, either to actually lay out the newsletter or just to prepare their copy and headlines.
2. The key to this activity is for the students to realize that they are actually producing something that will be distributed to a group outside of their class. They must keep this audience in mind at all times. The students may find it easier to write for a group which they are members of, rather than for an organization of which they have no knowledge.
3. On the other hand, the instructor might direct the students' efforts outside of the school to the community. A local organization or company could be contacted and used as the basis for the newsletter, providing an excellent source of public relations for the program.
4. Students should have approval from both their instructor and the advisor for the other organization before beginning work on the research project.
5. The instructor should look for 3-5 articles and 2-3 photographs in the finished project.

Instructional Strategy

- Discuss basic news writing skills (who, what, where, when, and why).
- Discuss basic page formats and layout.
- Provide instruction on use of the computer and software programs.
- Set up production deadlines for the student to meet *(or have the students do all this as part of their basic research).*
- Provide access to copy machine for reproduction and distribution of the newsletter.

Equipment/Supplies

1. Examples of newsletters
2. Blank layout sheets
3. Glue
4. Computer
5. Appropriate software programs
   Word processing (Microsoft Word®, PFS: Professional Write®, etc.)
   Desktop publishing (Aldus PageMaker®, PFS: First Publisher®, etc.)
6. Darkroom facilities and photographic materials
7. Copy machine

Evaluation Key

Evaluation of the research should be based on the students' completion and distribution of the newsletter as well as their knowledge of the terms and information covered in the preparation for the newsletter.

NEWSLETTER

Design, produce, and distribute a newsletter for a school organization.

Objectives

- To learn basic newswriting, page layout, and design skills.
- To produce a 2-4-page newsletter, containing articles and photographs, that will be distributed to an organization in the school or community.

Vocabulary

- Alignment—Placement of type on the page. *Flush left, flush right, justified* are used to define how the type looks.
- Body text—The main text of the story, separate from headlines or captions.
- Border—A frame around an element of the newsletter—stories, photos, illustrations or full pages.
- Byline—The name of the author of the story.
- Caption—The text describing a photograph or illustration.
- Columns—The basic building block of the newsletter. It determines the width of stories, headlines, photographs, illustrations, etc. A page can be divided into a single column, two columns, three, four, five, etc. Each element of the newsletter fits into the column(s).
- Crop—To trim a graphic element to fit a space without reducing the size of the graphic.
- Digitize—To convert an image into a series of dots that can be stored in the computer and manipulated or positioned into a document.
- Font—A specific typeface, such as Times (used throughout this book), Helvetica, Palatino, or ✹✪❒❁ ✣✻■✱✪✪▼▲ (Zapf Dingbats).
- Format—The overall appearance of a publication, including the size, margins, number of columns, fonts used, etc.
- Gutter—The space between two facing pages. Most elements (type, art, and photographs) should stay out of the gutter.
- Halftone—Rendering a continuous-tone photograph into a series of dots that can be reproduced with an ink process.
- Headline—The title of a story.
- Layout—The arrangement of text and graphics on a page.
- Nameplate—The design of the publication's name on the cover.
- Pica—A traditional typographic unit of measure. Six picas equal one inch.
- Point—The basic measure for type. Twelve points equals one pica. A 12-point type would be one pica tall. Seventy-two-point type would be six picas or one inch tall.
- Proofread—To check stories or articles for spelling, grammar, or punctuation errors. Very important!
- Sans serif—A typeface that does not have finishing strokes at the end of the characters. Helvetica is a sans serif typeface.
- Serif—A typeface that does have finishing strokes. Times is a serif type.
- Sidebar—A smaller story contained within a larger story. Usually boxed off with some type of frame.
- Spread—Two facing pages in a publication.
- White space—The areas of the page without any text or graphics. Used as an element of design.
- Widow—A single word or short line that is at the end of the paragraph. Should be edited out if it falls at the top or bottom of a page.

Concepts Reinforced

- Problem-solving skills
- Writing skills
- Design skills
- Photographic skills

Equipment/Supplies

- Blank layout sheets
- Glue
- Computer
- Appropriate software programs
  Word processing (Microsoft Word®, PFS: Professional Write®, etc.)
  Desktop publishing (Aldus PageMaker®, PFS: First Publisher®, etc.)
- Darkroom facilities and photographic materials
- Copy machine

Procedure

1. The first step in the production of a newsletter is learning some of the basic principles of newswriting, page layout and design, and use of the computer and software programs. Students should acquaint themselves with the 5 Ws of newswriting (who, what, where, when, and why), as well as the vocabulary listed above. The students should find examples of well-written articles from newspapers or magazines to use as reference materials.
2. Once the student has some basic skills in these areas, the next step is to define the purpose of the newsletter. Who is the audience going to be and what type of information would they be interested in seeing? The answer to these two questions should be included in the basic hypothesis for the research project.
3. Students should brainstorm for story ideas for the newsletter. A list of ten possible stories would be a good start. It is always better to have too many ideas than not enough. Story topics might include news about the organization's activities, award winners, profiles of individuals within the organization, etc. The stories need to be tailored for the appropriate audience (the members of the organization).
4. Stories, photographic assignments (either as illustrations for stories or as independent images), graphics, and illustrations should be assigned to members of the group. In addition, students should begin designing a rough layout for the newsletter. The students should look for other newsletters whose design they like, not to copy, but to give the group ideas on what they might do.
5. The rough layout should include information about the number of pages, a design for the nameplate, the basic column format for the newsletter and approximate spacing for stories, headlines, photographs, illustrations, and captions.
6. Once the stories have been written and typed into the computer, the pages should be formally laid out, with stories placed in their proper positions on the page. Photographs, headlines, illustrations and captions should also be placed into their correct areas on the layout.
7. After producing a final printout of the newsletter, or, if no computer is available, after typing out the stories and pasting them down, the students should paste down any graphics (photos or illustrations) that they plan to use.
8. Photocopy enough copies to distribute to the organization. In addition, produce enough copies for the other members of the Research and Development class so that the newsletter can be critiqued.

Support Materials

- Parker, Roger C. *The Makeover Book.* Chapel Hill, N.C.: Ventana Press, 1989.
- Shushan, Ronnie, and Don Wright. *Desktop Publishing by Design.* Redmond, Wash.: Microsoft Press, 1989.
- Magazines, newspapers, other organizational newsletters

RESEARCH AND DEVELOPMENT
INSTRUCTOR'S RESOURCE SHEET 24
(2-3 DAYS)

AERODYNAMICS OF FLIGHT

Essential Elements: Common: 2, 4, 6-10
Specific: 1, 3, 5, 7
TAAS Objectives: Language Arts: RC 1-7

Activity Summary
This activity will help the students understand the aerodynamics of flying and how it will affect a glider.

Teaching Tips
Because the students have little or no knowledge of aerodynamics and how it will apply to a glider design, this unit will give them information and vocabulary to work with.

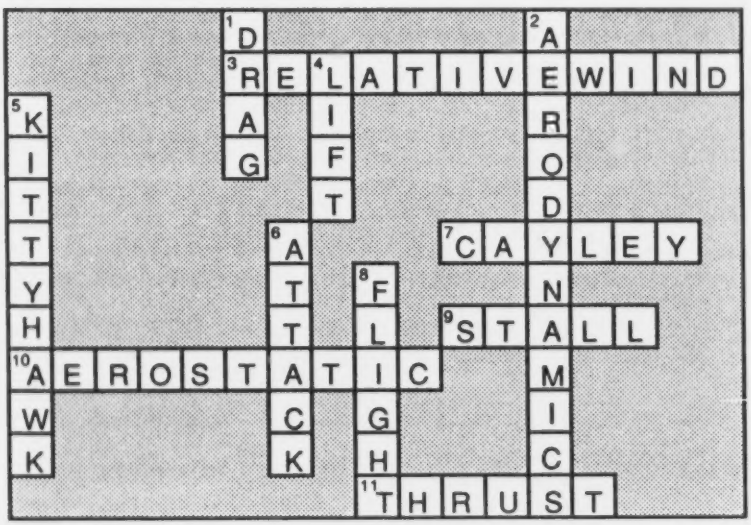
1. This can be a group or individual activity.
2. Basic knowledge of aerodynamics is not necessary but would be helpful.
3. The computer program *Flight Aerodynamics of Model Rockets* distributed by Estes will help the students understand aerodynamics.
4. Use Bernoulli's principal activity found in *Interfacing Math, Science, and Technology,* published by EIMC, 1987.
5. In the follow-up activities, expose the students to the terms and vocabulary presented.

Instructional Strategy
- Direct general questions to the class about aerodynamics before they start the unit.
- Summarize the unit and computer program.
- Introduce the vocabulary.
- Show video or 16mm films on aerodynamics.
- Go over transparencies with students.
- Pass out vocabulary list to the students before they start working on the computer program.
- Posttest the students after they finish the computer program.
- Have students work on crossword puzzle covering aerodynamics and the time line.

Evaluation Key
Students can be given a grade over the vocabulary list, the posttest, and/or the crossword puzzle.

Answers to the Posttest

1. A
2. (A) lift, (B) drag, (C) thrust, (D) gravity
3. aerodynamics
4. drag
5. gravity, drag
6. make the surface smoother
7. B
8. D
9. because the wing cannot be parallel to the relative wind
10. more lift
11. D
12. A
13. D
14. A
15. A
16. C
17. E
18. A
19. A



Crossword Puzzle Key

Across

3. relative wind
7. Cayley
9. stall
10. aerostatic
11. thrust

Down

1. drag
2. aerodynamics
4. lift
5. Kitty Hawk
6. attack
8. flight

AERODYNAMICS OF FLIGHT

Learn the forces of flight and how they play upon a glider.

Objectives
- To identify the four forces of flight
- To understand how related wind affects a flying object
- To gain knowledge of angle of attack and stall
- To learn how gliders, planes, and rockets fly

Vocabulary/Concepts Reinforced
- Aerodynamics
- Angle of attack
- Bernoulli's law
- Center of gravity
- Center of mass
- Drag
- Gravity
- Horizontal stabilizer
- Laminar air
- Lift
- Related wind
- Stall
- Vertical stabilizer
- Wing
- Wing chord
- Wing span

Introduction

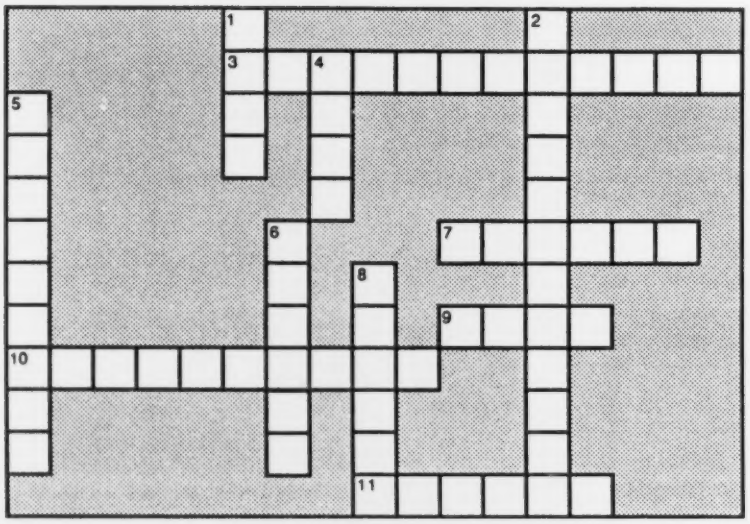
Gliders as well as airplanes are heavier-than-air machines. This is because they are heavier than the air they displace. Heavier-than-air machines depend on moving through the air so that the air flowing over their wings cause lift. The study of this behavior of moving air and the forces that it produces is referred to as aerodynamics, meaning "air in motion."

Procedure
1. Go through the computer program *Flight Aerodynamics of Model Rockets,* distributed by Estes.
2. Write out definitions of words on the vocabulary list as you go through the program.
3. Answer questions found on program.
4. Take posttest after reviewing program.
5. Work crossword puzzle.

Evaluation

You will be evaluated on
- vocabulary
- posttest
- crossword puzzle

Crossword Puzzle

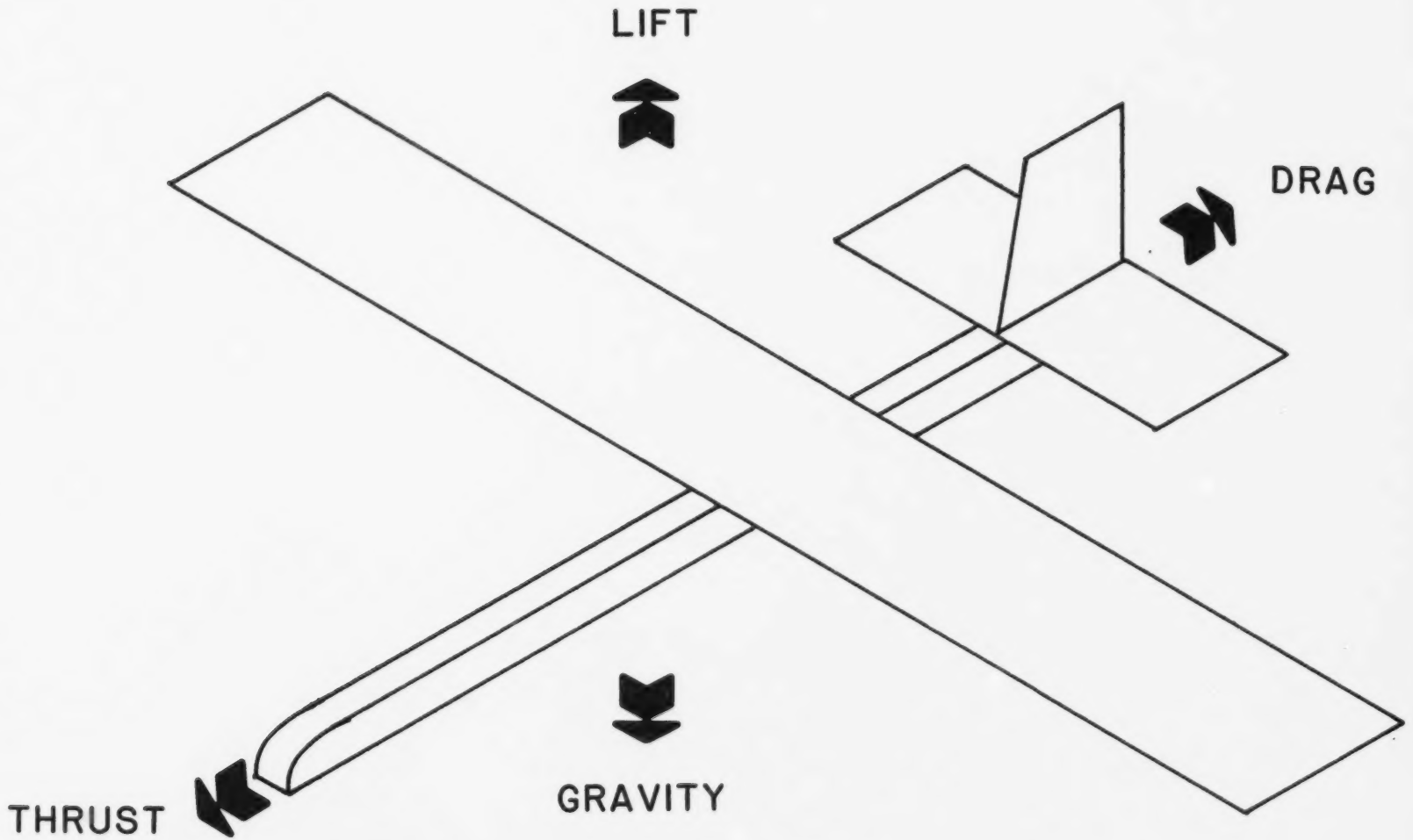


Across

3. The motion of air in relation to an object
7. Designed and built a human-carrying glider
9. Angle of attack at which the air flow becomes so irregular that the wing no longer generates lift
10. _____ vehicles (another name for balloons)
11. Forward force on a flying body

Down

1. Friction caused by air moving over an object
2. The study of the motion of air and bodies in the air and the force affecting their motion
4. The upward force generated by the relative wind past the wing
5. First power-controlled, sustained flight took place here
6. Angle of _____
8. Early man's attempts at this ended up in mythology



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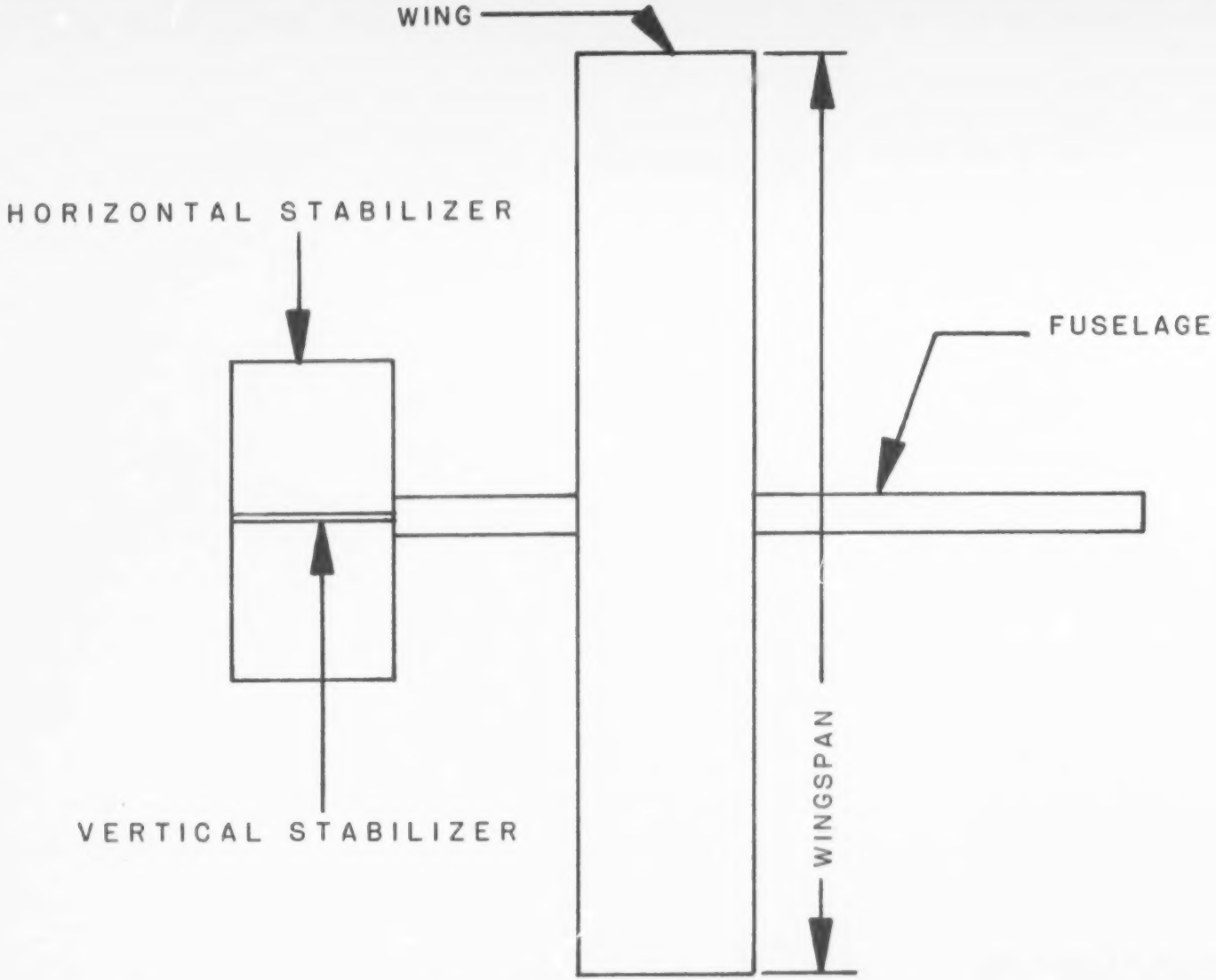
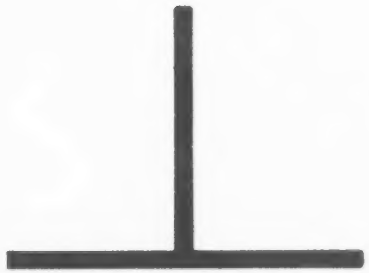
FORCES OF FLIGHT

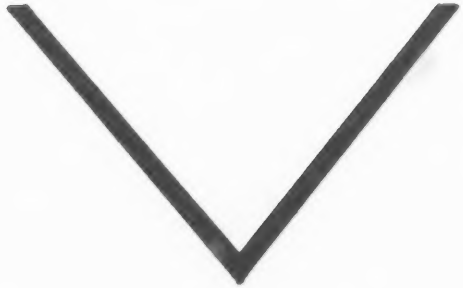


MAJOR PARTS OF A GLIDER

TAIL CONFIGURATIONS



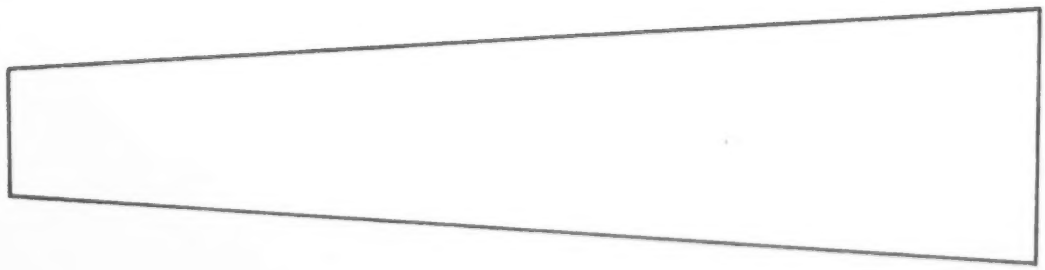
CONVENTIONAL TAIL



V-TAIL

T-TAIL

WING PATTERNS



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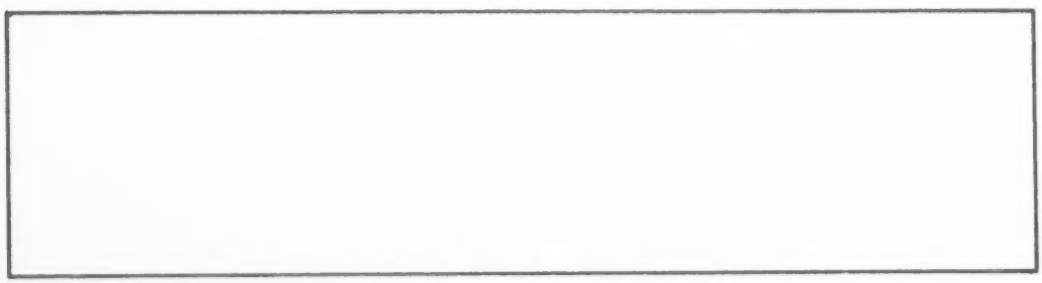

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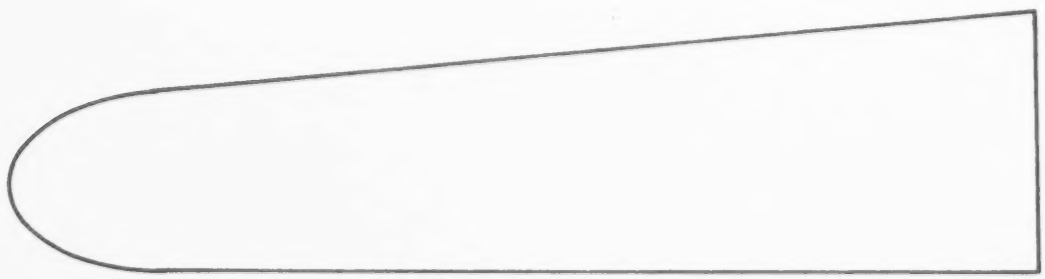
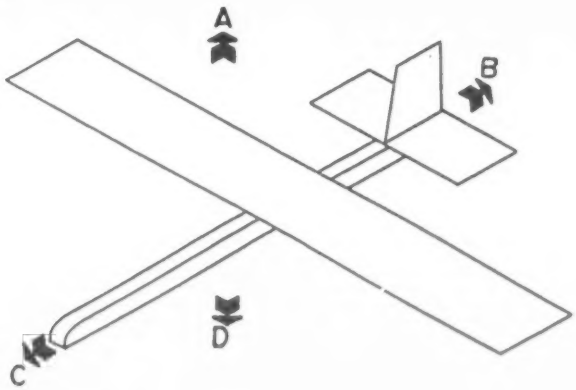


ELLIPTICAL

Posttest: Aerodynamics of Flight

1. The apparent motion of the air related to an object in it is called _____.
   A. relative wind
   B. airflow
   C. air current
   D. a breeze
2. Identify the forces of flight indicated.
   A. _____
   B. _____
   C. _____
   D. _____



FORCES OF FLIGHT

3. _____ is the study of the motion of air and bodies in the air and the forces affecting their motion.
4. _____ is the aerodynamic force which has the greatest effect on the flight of a glider.
5. Name the two forces that limit the height a glider will reach.
   _____ and _____.
6. What can be done to minimize the effect of drag on a glider? _____
   _____
7. If a glider is flying straight and there is no wind, which force is moving toward the glider?
   A. drag
   B. relative wind
   C. gravity
   D. thrust
8. Airplanes and gliders use wings to help them remain in the air. The wings are designed to produce _____.
   A. drag
   B. speed
   C. thrust
   D. lift
   E. straight flight
9. If a wing is flat on the top and bottom and the air flows smoothly past it at equal speeds above and below it, why is no lift generated? _____
   _____
10. If relative air moves faster over a wing at 15 degrees than at 10 degrees, what is the effect on lift? _____

11. The angle between the horizontal and a line through the center of the wing is called _____.
    A. lift factor
    B. stall factor
    C. angle of lift
    D. angle of attack
12. If the front of the glider wing becomes progressively higher than the rear of the wing, then the amount of _____ produced increases.
    A. lift
    B. stall
    C. angle of attack
    D. gravity
13. As the angle of attack increases, more _____ is produced.
    A. relative wind
    B. stall
    C. drag
    D. lift
14. When airflow over a wing becomes so irregular that the wing no longer generates effective lift, a condition called _____ happens.
    A. stall
    B. lift
    C. dive
    D. glide
15. When the wings do not produce enought lift, a glider can go into a rapid downward motion called a dive.
    A. true
    B. false
16. If a glider's wing has a negative angle of attack, it goes into a _____.
    A. stall
    B. glide
    C. dive
    D. climb
17. When a glider goes into a dive, the wings must produce lift to overcome what chief force?
    A. drag
    B. stall
    C. friction
    D. thrust
    E. gravity
18. A glider must move forward and at the same time lose altitude. The slower it loses altitude after a gentle toss, the better it is.
    A. true
    B. false
19. Is a glider affected by the pull of gravity, no matter what the angle of attack of the wing?
    A. yes
    B. no

SKETCHING A GLIDER DESIGN

Essential Elements: Common: 8-10
Specific: 3-7
TAAS Objectives: Mathematics: C 3
O 1-4
PS 3

Activity Summary

The students will draw a freehand sketch using graph paper, pencil, eraser, along with proper sketching techniques, to create a three-view design of a proposed glider. The students may design a glider for distance, duration of flight, and/or both in one design.

Teaching Tips

1. This can be a group or individual design assignment.
2. Students should be familiar with the design concepts.
3. A CAD system could be integrated into the design process to enhance the glider design.
4. Designs should be simple, but follow aerodynamics guidelines taught through lecture, handouts, films, and computer programs.
5. Continually hint that balance and weight of the glider are essential.

Instructional Strategy

Remind the students of their choice of designs, length of flight (in feet), duration of flight (in seconds), or both. Allow the students to experiment with designs; however, give them specifications to work within. Example: maximum fuselage length, maximum wing span. The students should use graph paper, pencil, and eraser (no aids of any kind) to develop a design. Emphasize that the students keep the design in proportion.

Equipment/Supplies

1. Paper
2. Pencil
3. Eraser
4. Videotape player or 16mm projector
5. Computer and software

Evaluation Key

1. The use of freehand sketching techniques
2. Proper line use
3. Sketch is kept in proportion
4. Proper orthographic projections concept

Support Materials

- *Airplanes and How They Fly.* 15 min. Color Film • Video, Regional Service Center.
- *Glidepath.* Computer Program published by Ahrm Software, 175 Tompkins Ave., Pleasantville, N.Y. (Apple II+, IIe, IIc w/64K).
- Smith, Hubert "Skip." *The Illustrated Guide to Aerodynamics.* Blue Ridge Summit, Penn.: Tab Books, Inc., 1985.

SKETCHING A GLIDER DESIGN

Design a glider.

Objectives
- To apply the design process
- To use proper sketching techniques
- To use orthographic projection concepts
- To put to use aerodynamic information

Vocabulary/Concepts Reinforced
- Design process
- Sketching as a tool in designing
- Orthographic projections in the design process
- Thumbnail sketching

Equipment/Supplies
- 12 x 18 graph paper
- Pencil
- Eraser

Introduction
Freehand sketching is a quick and convenient means of putting an idea into graphic form. Sketching is the beginning of the design process. Usually it starts with several thumbnail sketches. The next step in the design process is to select one of the thumbnail sketches and do a more detailed sketch, which is followed by revision after revision until it is ready to be turned over to a drafter. At this point the sketch will be drawn up as a working drawing.

Procedure
1. Obtain maximum specifications for glider fuselage and wingspan.
2. Go over information on wing patterns, wing placement, horizontal and vertical stabilizer configuration.
3. Sketch several thumbnail designs.
4. Select one of the thumbnail designs for refinement.
5. Use graph paper, and sketch the final design using proper sketching techniques.
6. When sketching, keep the parts in proportion.
7. Have instructor check the design.

Evaluation
The students should be aware of proportion, accuracy, view placement, and line usage. The finished sketch should communicate the shape and characteristics of the design.

DRAWING GLIDER PLANS

Essential Elements: Common: 8-10
Specific: 1, 4, 5, 6
TAAS Objectives: Language Arts: RC 4
WC 1-4

Activity Summary

The students will make a working drawing of their glider design using their own or another student's design. The drafter will use the sketch that was completed in the last unit.

Teaching Tips

1. Go over the sketches to make sure the students understand the design.
2. Review working drawings.
3. Review dimensions and notes.
4. Review line usage.
5. Review centering a drawing.
6. A CAD program could be integrated into this unit.

Instructional Strategy

- Relate content to how industry goes through the design process.
- Relate content to prior learning.
- Provide opportunities for the transfer of learning.

Equipment/Supplies

1. Paper
2. Tape
3. Scale
4. Drawing pencils
5. T square
6. Triangles
7. Flex curve
8. CAD program
9. Blue line paper
10. Blue line machine
11. Blue line printer

Evaluation Key

1. Use usual drafting evaluation techniques.
2. Give the students the opportunity to do revisions. (See "Revisions on Drawings," Module 10 in *Manufacturing Graphics*, Austin: EIMC, University of Texas, 1988, p. 75.)

DRAWING GLIDER PLANS

Change a sketch into a working drawing.

Objectives
- To make a working drawing for the construction of a glider prototype
- To transfer information from a sketch to a working drawing
- To review manufacturing graphics drawing procedures and techniques
- To simulate industrial procedures

Vocabulary/Concepts Reinforced
- Drafting procedures and techniques
- Engineer to drafter

Equipment/Supplies
- Drafting paper
- Tape
- Scale
- Drawing pencils
- T square
- Triangles
- Flex curve
- CAD software
- Plotter
- Blue line paper

Introduction
Drafting is that part of industry concerned with the preparation of drawings used in the construction of modern products. However, before these modern-day products can be constructed, they must be accurately drawn both in size as well as shape. This gives the designers a complete graphic illustration of the finished product.

Procedure
1. Using the sketch previously drawn, select a scale that will allow the glider design to fit the size drawing paper being used.
2. Use the designated layout-to-sheet-size to center the drawing using spacing formulas.
3. Produce an instrument drawing using information, size, and shape found on the sketch.
4. Use ANSI standards.
5. Use proper standards for all lettering.
6. Use designated dimensioning style.
7. Draw three views and any other needed descriptions such as sections and/or auxiliaries.
8. Make a blue line or diazo print of the pencil drawing upon completion of drawing.
9. After the drawing has been graded, go back and make any revisions and corrections needed and repeat step 8.

Evaluation
The finished drawing will be graded by the instructor by usual drafting evaluation techniques according to accuracy, lettering, line quality, neatness, and dimensioning.

BUILDING A GLIDER PROTOTYPE AND ANALYZING THE DESIGN

Essential Elements: Common: 2, 4, 6, 10
Specific: 1, 3, 5, 6, 8-10
TAAS Objectives: Mathematics: C 3
O 1-4

Activity Summary
In this activity the students will build a working model using their plans as a guide for construction. After constructing their model the students will analyze the design through test flight and record keeping.

Teaching Tips
1. Before issuing balsa wood to the students, have them cut out patterns for fuselage, wings, vertical stabilizer, and horizontal stabilizer from a copy of the diazo print made from the pencil working drawing.
2. Go over with students safety rules for using X-acto knives.
3. Issue balsa wood.
4. Weight and balance of the glider are important to its flight or it will not perform to expectation. If the glider has too much weight toward the nose, it will dive. On the other hand, the glider will stall if there is too much weight in the tail. The weight and balance can be overcome by either moving the wings forward or backward or by increasing or decreasing the nose weight.

Equipment/Supplies
1. 1/8 x 3 x 36 balsa wood for fuselage
2. 1/16 x 3 x 36 balsa wood for wings, vertical stabilizer, and horizontal stabilizer
3. X-acto knife
4. Cutting pads
5. 220 sandpaper
6. Rubber bands for holding wing to fuselage
7. Hot glue gun
8. Glue sticks
9. Paper clips for nose weight
10. Scissors

Evaluation Key
Grade using usual project grading standards.

BUILDING A GLIDER PROTOTYPE AND ANALYZING THE DESIGN

Construct and test the design.

Objectives
- To apply the design process
- To construct a model from working drawings
- To analyze the design

Vocabulary/Concepts Reinforced
- Design process
- Aerodynamics principles

Equipment/Supplies
- 1/16" thick balsa wood for wings, vertical stabilizer, and horizontal stabilizer
- 1/8" thick balsa wood for fuselage
- X-acto knife
- 220 sandpaper
- Rubber bands
- Glue
- Paint
- Brush
- Thinner

Introduction

With this unit the finished working drawing will supply the information for constructing a working model of a glider. Upon completion of the model, several test flights will be conducted to see if the glider reacts as expected. If the glider does not react as expected, it will most likely be due to problems with weight or balance, or both. If the model's tail drops, the tail is too heavy. This can be overcome by adding weight to the nose or moving the wings to a new position, usually forward. However, if the model's nose drops and dives, take weight from the nose or move the wings back toward the stabilizers.

Procedure

1. Cut out patterns for the fuselage, wings, and vertical and horizontal stabilizers.
2. Tape patterns to proper balsa wood—1/8" for fuselage and 1/16" for wings and stabilizers.
3. Use X-acto knife to cut out patterns. Place something under wood to protect tabletops.
4. Sand each piece before assembling.
5. Assembly glider stabilizers can be attached with hot glue. The wings can be cut in half, across the chord, then attached with hot glue, or use a full wingspan and attach with a rubber band to the fuselage. Using a rubber band will allow the wing to be moved to help the weight and balance.
6. Test fly the glider and analyze the flight. If the glider climbs then stalls, the tail is too heavy. Adjust the weight by adding more weight to the nose or move the

wings forward on the other band. If the glider nose dives, remove nose weight or move the wings toward the tail.

7. After all testing and the glider performs as wanted, paint it and give it a number for identification.
8. If any changes in design are made, such as wing placement, wingspan, wing chord, etc., these changes should be noted and changed on the working drawing. Be sure to note revisions and the date of revisions so that an accurate record is kept on the glider's design changes.

Evaluation

The finished glider will be graded on workmanship and how well it matches the design shown on the working drawing.

IMPLEMENTING THE FINAL DESIGN

Essential Elements: Common: 2, 4, 7, 10
Specific: 5, 6, 8
TAAS Objectives: Mathematics: O 3
PS 1-4

Activity Summary
Students will fly their gliders for a set number of flights and keep records of each performance.

Teaching Tips
1. Review the fundamentals of aerodynamics.
2. Remind the students that their design will be tested for length of flight (distance), duration of flight (time), or both.
3. With each flight the students will keep records of distance, time of flight, wind direction, and, if possible, wind speed.
4. Have student spotters to mark distances and to retrieve gliders.
5. Use a large area inside such as a gym.

Instructional Strategy
This activity can be a very competitive part of the unit. Allow the students to have several flights to adjust the glider. Before starting the competition, set the number of flights the students will be graded on; five to ten flights would work. Throw out the worst flight, and average the remaining ones.

Equipment/Supplies
1. 100' tape measure
2. Stop watch
3. Clipboard
4. Chart for recording time and distances

Evaluation Key
Set up a performance scale by which to grade the students' gliders.

IMPLEMENTING THE FINAL DESIGN

Fly the glider for distance or duration.

Objectives
- To evaluate glider design to see if it performs as planned

Vocabulary/Concepts Reinforced
- Fundamentals of aerodynamics

Equipment/Supplies
- Finished glider design
- 100' tape measure
- Pencil

Introduction
In this unit you will be evaluating and recording information on the performance of your design. Keep accurate records as you will be asked to use this information in the next unit.

Procedure
1. The final flight of your design will be in a large area such as a gym or auditorium.
2. Determine, if any, the wind direction, and fly the glider into the wind for maximum lift.
3. Make a test flight and make any adjustments for the area in which the flight takes place.
4. Make five flights of the glider. After each flight, record distance and/or time, as well as the direction of the flight, such as straight and right or left of center.
5. When calculating the average of the five flights, throw out the worst flight and divide the total of the other flights by four.

Evaluation
The grade will be based on the average of the four flights.

MODEL WIND TUNNEL

Essential Elements: Common: 1, 2, 4, 6, 7, 9, 10
Specific: 1, 2, 4, 6-8
TAAS Objectives: Mathematics: C 4
PS 2, 4

Activity Summary

This activity is a long-term project that will allow a student to research the component systems of a wind tunnel. These subsystems include the wind source, intake, test section, exhaust section, and smoke system. Each system will offer a design problem in itself.

Teaching Tips

1. This project requires quite a bit of ingenuity. Do not hesitate to try even the strangest sounding options.
2. Use any resources available to you. Check with the science department for suggestions.
3. Safety is very important. Design all tests to ensure the safety of the participants. Evaluate possible solutions very carefully with respect to safety.
4. Be patient! The final design will very likely be much different from the original.
5. This is a research project. Do not criticize solutions that do not prove to be effective. Analysis and modification (problem solving) are the most important aspects of this exercise.

Equipment/Supplies

1. Varies with options selected

Evaluation Key

Grade using usual project grading standards.

MODEL WIND TUNNEL

Design and test a classroom size wind tunnel.

Objectives
- To understand the basic components of a wind tunnel system
- To investigate alternative solutions for the components of the system

Vocabulary/Concepts Reinforced
- Velocity
- Drag
- Friction
- Coefficients

Equipment/Supplies
- Varies with solution chosen

Introduction
Wind tunnels are used to demonstrate and evaluate the aerodynamics of an object. A wind tunnel is composed of several different component systems such as a wind source, intake, test chamber, smoke system, and exhaust system. These systems must be balanced with each other in order to make an effective wind tunnel model.

Procedure
1. Wind tunnels come in many different shapes, sizes, and configurations. First, research wind tunnel design and make a list of the systems that make up a wind tunnel and the different methods used to create these systems.
2. The systems used in this wind tunnel model will be as follows: wind source, intake, test chamber, smoke system, and exhaust system. Each system will be discussed separately. After the discussion of each system, make a list of possible solutions available for a model tunnel.
3. The wind source is available in many different forms. Two distinct items must be considered: the method of propulsion and the power source. Propulsion of the air can be achieved through a simple household fan, a blower fan (squirrel cage), an airplane propeller, etc. The size of the intake area and also the amount of air required must be considered when choosing the type of propulsion. One critical item is to make sure that the size of the fan or prop is nearly equal to the size of the intake. This will assure that air movement is the same in all areas of the tunnel. The main consideration for a power source is maintaining the constant operation of the propulsion system. Examples of power sources include batteries, small model vehicle engines (gas and battery), or AC electricity.
4. The intake system has a direct effect on the movement of the air in the test section. An example of why an intake system is necessary would be shown when a household fan is used as a wind source. The fan produces air currents having a rotational motion. A blower (squirrel cage) fan will produce more of a rolling motion of the air in the tunnel. Both types of rotation will be seen in the test section as the smoke is introduced. To eliminate this, a set of baffles must

be constructed to stop the rotation. Other wind sources may require different designs of the intake system.

5. When you are designing the test section, consideration must be given to items such as the size of the object to be tested, construction materials, the shape of the test section, the method of supporting the object inside the test section, the shape of the intake system, etc. Do not forget that visibility is important in the test section. Use either a transparent material such as Plexiglas for construction or make a viewing area with clear acetate in opaque materials.
6. At the end of the tunnel is the exhaust system. The design considerations for this area are similar to those for the intake system. When the air exits the test section of some tunnels, a backwash effect may occur that interrupts the flow of air through the test section. Once again, a set of baffles will solve the problem. One suggestion is to design this system last simply because backwash may not occur and therefore an exhaust system would not be necessary.
7. The actual aerodynamic properties of a shape will be observed as smoke passes over the object. The smoke system offers many options. Experiments with the alternatives are required in order to choose the appropriate system. The smoke can be made by dry ice, steam, mixing hydrochloric acid and ammonium hydroxide vapors (check with your science department), "fog machine juice" (available at music stores), etc. Research different materials that will produce a vapor that is dense enough to be visible and also long-lasting enough to travel the entire length of the wind tunnel. "Fog machine juice" emits a dense smoke when heated. Tests done with the "fog machine juice" include different methods for vaporizing the liquid. Examples of such tests are heating a 1/4" copper tubing coil with a hot air gun, attaching the copper coil to a hot plate, changing the diameter of the tubing using both larger and smaller diameters, changing the lengths and shapes of the coils, heating a covered pot with a hot plate while forcing air through the pot, adjusting the volume and pressure of the air flowing through the pot, etc. Many such tests can be done easily. The location for the introduction of the smoke into the system is also a question. Placing the smoke inlet between the intake and wind source will give different results from placing the inlet between the intake and the test section.
8. These are the major sections of a wind tunnel. After the separate systems have been researched, the options for implementation must be evaluated and a solution chosen. One such solution is illustrated in figure 1. The model may begin with the construction of any one of the systems. As construction progresses, the whole solution must be kept in mind as individual areas are modified.

Evaluation

The finished wind tunnel will be graded on workmanship on the various components and research on and approach to design problems.

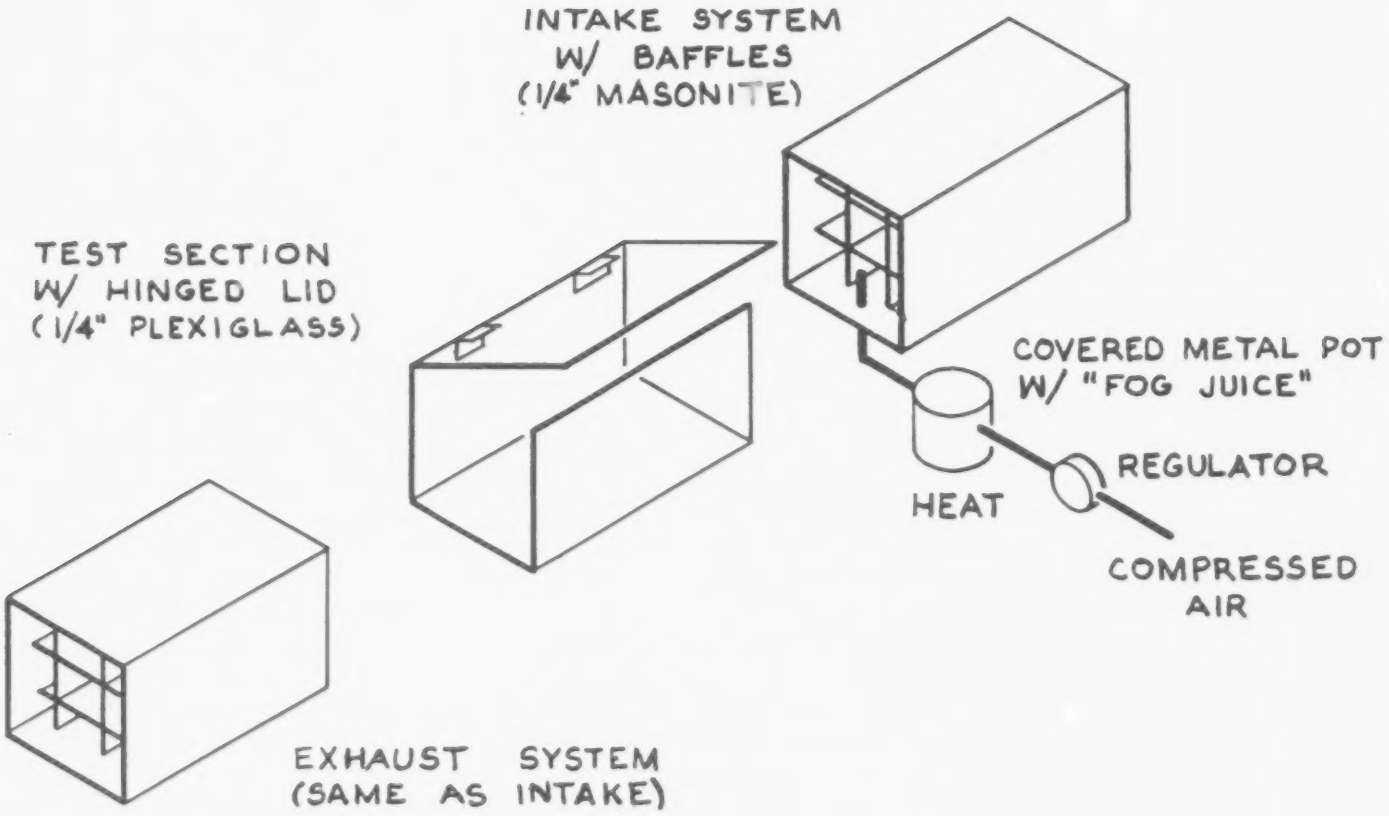

INTAKE SYSTEM
W/ BAFFLES
(1/4" MASONITE)
TEST SECTION
W/ HINGED LID
(1/4" PLEXIGLASS)
COVERED METAL POT
W/ "FOG JUICE"
REGULATOR
HEAT
COMPRESSED
AIR
EXHAUST SYSTEM
(SAME AS INTAKE)

Figure 1

SOLAR-ASSISTED VEHICLE

Essential Elements: Common: 1, 2, 4, 6-10
Specific: 1, 2, 4, 6-8
TAAS Objectives: Mathematics: C 1 2, 4
PS 1-4

Activity Summary
Students will experience and evaluate the performance of a vehicle whose power source has been altered to include a solar panel.

Teaching Tips
1. Carefully discuss the proper use of multimeters. Check the circuit before allowing the student to run the test.
2. Allow a partner to assist in making measurements during testing.

Instructional Strategy
- Discuss the basics of electrical circuits, including voltage, current, resistance, load, measurement, etc.
- Discuss the need for consistency during testing in order to make accurate comparisons of data.
- Discuss possible sources of error.
- Allow the student to design other tests for evaluation of performance.

Equipment/Supplies
1. Battery-operated, radio-controlled vehicle
2. Solar panel
3. Multimeter (2)—must be capable of reading DC current up to 10A
4. Dynamometer (see illustration)
5. Battery charger and batteries
6. Miniature on/off switch
7. Wire jumpers with alligator clips

Evaluation Key
Upon completion of tests, the student will evaluate and describe the results. These will be compared to the student's predicted outcomes. Explanations for differing results should be offered.

SOLAR-ASSISTED VEHICLE

Test the effects of a solar panel on the performance of a battery-operated, radio-controlled vehicle.

Objectives
- To investigate the characteristics of simple electrical circuits
- To investigate the characteristics of commercially available solar panels
- To test the performance before and after the inclusion of a solar panel as a source of power
- To record, chart, and analyze data from the testing procedure

Vocabulary/Concepts Reinforced
- Photovoltaic
- Current (DC, AC)
- Voltage
- Resistance
- Measurement
- Load
- Dynamometer
- Electric circuits (series, parallel)

Equipment/Supplies
- Battery-operated, radio-controlled vehicle
- Solar panel
- Multimeter (2)—must be capable of reading DC current up to 10A
- Dynamometer (see illustration)
- Battery charger and batteries
- Miniature on/off switch
- Wire jumpers with alligator clips

Introduction

Vehicle manufacturers are always looking to improve the performance of their vehicles. One method is to use solar energy as a power source for the vehicle. The first step of this project is to read information on solar-powered vehicles with emphasis on the use of solar panels in the design. After researching the way these panels are used, students will construct a test vehicle. A method of testing the vehicle to determine the effects of the solar panel must also be designed.

Procedure

The test vehicle is simply a vehicle with a solar panel mounted on top of the chassis. The method of attaching the solar panel will vary greatly with the design of the panel and the vehicle.

Next is the design of the testing procedure. There are several tests which can be run on the vehicle. Listed below are some examples:

1. No load without a solar cell—discharge the batteries of the vehicle at full speed with the rear of the car elevated and the wheels spinning freely.
2. No load with a solar cell—same as #1 with the solar panel included as a power source.

3. Load without a solar cell—discharge the batteries of the vehicle at full speed using a dynamometer (see illustration) to place a load the motor.
4. Load with a solar cell—same as #3 with the solar panel included as a power source.

Carefully study the diagram that shows how the multimeters and other electrical components are assembled to collect data during testing. Also, design a form which will be used to record the data collected. A sample form is included.

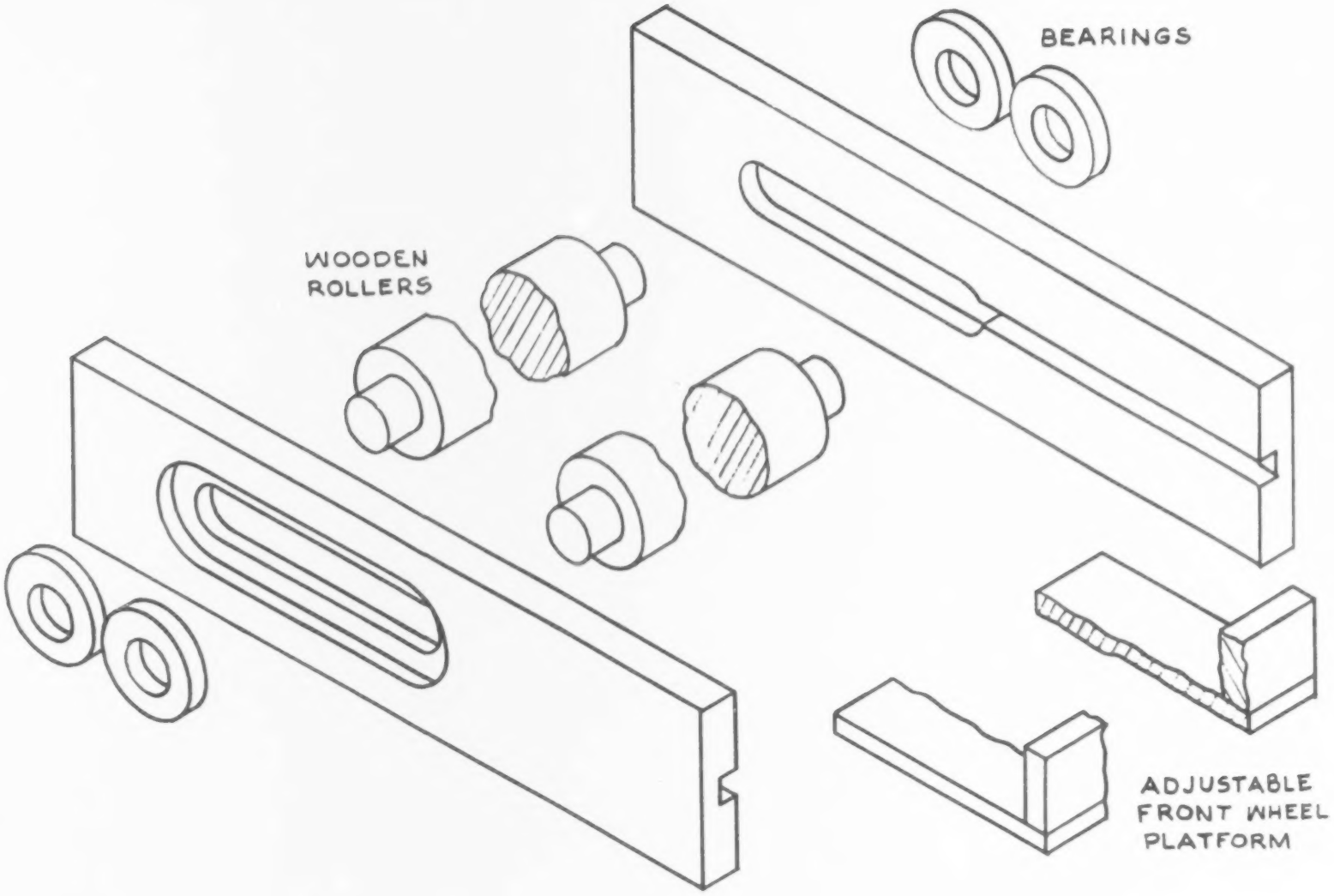
The effect of the solar panel can be seen in several different areas. Examples are the total discharge time of the battery pack, the amount of current drawn by the motor, the amount of voltage applied to the motor, and the voltage output of the solar panel. Outlined below is a sample testing procedure. Upon completion of these tests, design tests of your own and determine the effects of the solar panel on the performance of your vehicle.

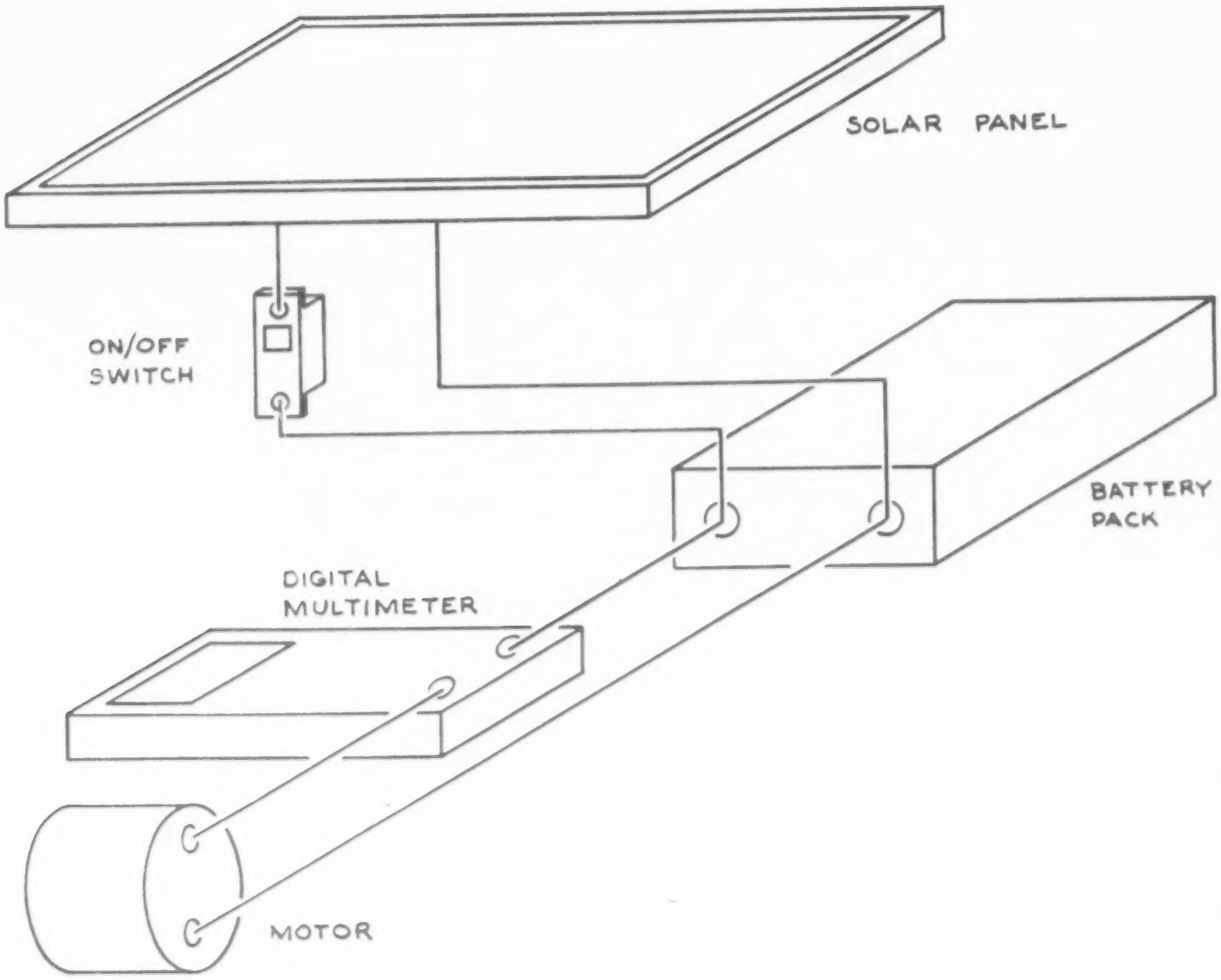
Sample Testing Procedure

1. Prepare the materials listed above.
2. Predict the outcome of each of the four tests described above.
3. Completely discharge the batteries for the vehicle.
4. Place the batteries in the charger. To eliminate error they must charge for the same amount of time in between the different tests.
5. Assemble the test vehicle, multimeters, and other components as shown in the diagram.
6. Install the batteries in the test vehicle.
7. Start the vehicle and maintain the highest rpm possible during the test.
8. Record the readings from the multimeters on the form provided.
9. Prepare graphs comparing the elapsed time with the current, motor voltage, and solar panel voltage for each of the four tests. Analyze your results and draw conclusions as to the effect of the solar panel on the performance of the vehicle.
10. Compare the actual results to your predictions, and determine any sources of error.

Evaluation

Upon completion of tests, the student will evaluate and describe the results. These will be compared to the student's predicted outcomes. Explanations for differing results should be offered.


BEARINGS
WOODEN ROLLERS
ADJUSTABLE FRONT WHEEL PLATFORM


SOLAR PANEL
ON/OFF
SWITCH
BATTERY
PACK
DIGITAL
MULTIMETER
MOTOR

Solar Vehicle Test Data

Description of Test: _____

_____

_____

Elapsed Time	Current Voltage	Motor Voltage	Solar Panel
1 min			
2 min			
3 min			
4 min			
16 min			
17 min			

Total discharge time: _____

Notes: _____

ENGINEERING MODEL BUILDING

Essential Elements: Common: 2, 6, 8, 9, 10
Specific: 2, 3, 5, 8
TAAS Objectives: Language Arts: RC 1-7

Activity Summary

This activity is intended to provide Research and Development students with an advanced engineering problem. Students will work either in small groups or independently to construct an engineering model. The model described in this activity can be used as a stand-alone project or as one of four components of a larger project. The advantage of using this activity in combination with the other sections is that the model must be constructed with careful accuracy in order to fit the other components.

Teaching Tips

1. Discuss with your students the importance of model building as a method to enhance the design and construction of complex engineering projects.
2. Make a sample model for students to observe. Completing one of the model kits will also help the instructor determine the length of time necessary for his/her particular students to complete the project.
3. Cover general safety procedures for handling hand tools and adhesives necessary to construct the models.

Instructional Strategy

- Use this as either a small group or individual activity.
- This activity mirrors actual modeling techniques used in the design and construction of engineering piping systems.
- If time permits, this activity could be used as a group project to simulate the task of an engineering company to design and build a project. All of the pipe flowcharts, engineering plans, etc., are included in the kits. Students could organize themselves into a simulated company, assume the various responsibilities, and work as an engineering team to construct the finished project.

Equipment/Supplies

1. Basic design mini-kits available from:
   Plastruct, Inc.
   1020 South Wallace Place
   City of Industry, CA 91748
2. Drawing or plan table—Note: If possible, change the arrangement of your lab area to accommodate this project. It may be best to have space for the students to spread out their materials.
3. Plastic adhesive
4. Various hand tools as needed

Evaluation Key

1. Instructor evaluation of this activity should be based on accurate completion of the activity.

2. If this activity is used as a group project in which the kits are to be combined into a single finished product, they should fit together as accurately as if constructed as a single kit.

ENGINEERING MODEL BUILDING

Complete an engineering model to study the use of modeling in the design and construction of complex engineering projects.

Objectives
- To use modeling techniques to enhance the design and construction of an engineering project
- To read a set of basic piping or engineering drawings
- To assemble a scale model from a set of plans and specifications

Vocabulary/Concepts Reinforced
- Flow diagrams
- Structural drawings
- Arrangement drawings
- Equipment drawings
- Pump and rack drawings
- Pipe flowcharts

Equipment/Supplies
- Basic design mini-kit
- Planning and work tables
- Plastic adhesive
- Various hand tools as needed

Introduction
This activity is intended to provide the Research and Development student with a hands-on engineering problem. Students working either individually or in small groups will complete one of four engineering model kits. These kits can be used as single projects or can be combined in sets of four to construct one more complex project. Students will use flow diagrams, structural drawings, arrangement drawings, equipment drawings, and pump and rack drawings to complete their project.

Background Information
Engineering model building has been used extensively in the design and construction of petroleum refineries, petrochemical plants, power plants, and factories for many years. Although the development of three-dimensional CAD systems has helped the design and drawing stages of these facilities, many engineering companies feel that the three-dimensional scale model provides a much better constant reference. Engineering models serve the engineer throughout the project, from the design phase until all construction is finished.

Procedure
1. Select the design kit that you wish to construct.
2. Read through all of the literature in the kit to ensure that you know exactly what to do with the plans and materials.
3. Cut and assemble the parts as accurately as possible. All measurements are scaled accurately.

4. Upon completion of the activity, display your finished project for other students to view.

Evaluation

Instructor evaluation of the activity will be based on careful completion of the design mini-kit. If the four mini-kits are to be grouped together as a single project, all pipe and fitting connections should be aligned correctly.

TRUSS DESIGN AND TESTING

Essential Elements: Common: 6, 8-10
Specific: 5

TAAS Objectives: Language Arts: RC 1-4
Mathematics: C 2
O 1-4
PS 3

Activity Summary

This activity is designed to provide advanced-level students in Construction Systems, Construction Graphics, or Production Systems with a research problem in which they perform strength tests on a variety of truss designs. Students will be given a set of standard specifications for span and roof pitch and will then build and test selected truss designs for maximum load-bearing capacity.

Teaching Tips

1. Encourage precision and craftsmanship in the fabrication of the truss designs. The teacher should perform some type of quality control check during fabrication. It is advisable to have students draw their trusses on heavy drawing paper or use a pattern from which to build their trusses.
2. Limit the activity to three or four truss types per student. If you have several students working on this activity, vary the types of trusses used by each student in order to get a variety for testing.
3. Review safety procedures for various machines and tools if necessary.
4. Build the truss testing device before beginning the activity.
5. Display the student projects in an area of the school where other students and faculty can view the work.

Instructional Strategy

- Use a group discussion to present the topic to students.
- Use support material as necessary by providing students with technical reference material.
- Use the activity as either an individual or small group project.
- Have students write a short technical paper describing their project. It should include drawings, charts, etc., which they have used.

Equipment/Supplies

1. ¼" untempered Masonite cut to scale (1" = 1'0"). Note that you can use just about any wood material for this activity that you find easy to work with.
2. Hot glue gun and glue sticks
3. ¾" plywood for testing base (see diagram)
4. Miscellaneous nails and glue for assembling testing base

Evaluation Key

Instructor evaluation will be based on student participation in the activity as well as on a written technical report which summarizes the testing results.

Support Materials

- American Institute of Timber Construction
  333 West Hampden Ave.
  Englewood, CO 80110
- Truss Plate Institute
  7100 Baltimore Ave.
  College Park, MD 20740
- Any construction literature in which truss designs are discussed

TRUSS DESIGN AND TESTING

Construct and test several different truss designs for load-bearing efficiency.

Objectives

- To understand the concept of engineered truss design
- To apply engineering factors to a practical research and testing activity

Vocabulary/Concepts Reinforced

Note: Numbers in parentheses refer to figure 1.

- Axial force—A push (compression) or pull (tension) acting along the length of the truss member. The force is measured in pounds or metric equivalents.
- Bearing—(1) A structural support of a truss; generally, a wall or a beam.
- Bending moment—A measure of the bending effect on a truss member due to loads imposed perpendicular to that member.
- Camber—An upward vertical displacement, or arching, of the bottom chord, built into the truss to compensate for expected deflection.
- Cantilever—(2) The structural portion of a truss that extends beyond the end support or bearing.
- Chord (bottom)—(3) The sloping or horizontal member of a truss that establishes the lower edge of that truss.
- Chord (top)—(4) The sloping or horizontal member of a truss that establishes the upper edge of that truss.
- Clear span—(5) The horizontal distance between interior edges of any two adjacent supports of a truss.
- Connector plate—(6) A steel gusset with prepunched pointed teeth used to securely fasten the individual truss members together to form a unified truss.
- Deflection—The downward movement of a truss due to the live or dead loads imposed on it.
- Double top plate—(7) The two horizontal wood members that run across the tops of the vertical studs in a wall and form the support area for the trusses resting on the walls.
- Heel—(8) Point on a truss at which the top and bottom chords of a truss intersect.
- Lateral bracing—(9) A member which is placed and connected at right angles to a chord or web member of a truss.
- Load—The design weight requirements of a truss consisting of several categories of loading conditions. They are:
  A. Live load—any loading not of a permanent nature, such as snow, wind, construction materials, etc., usually specified by local building codes.
  B. Dead load—any loading that is permanent in nature, such as decking, roofing or flooring materials, purlins, ceiling materials, even a member's own weight.
- Nominal span—(10) Horizontal distance between outside edge of supports including all cantilevers.
- Overhang—(11) The extension of the top chord beyond the edge of the outside wall.
- Panel (bay)—(12) The span of chord measured horizontally and delineated by two successive joints or panel points.
- Panel point—(13) The point at which one or more webs meet a chord.
- Peak—(14) The point on a truss where the sloped top (or bottom) chords meet.
- Pitch (slope)—(15) The amount of vertical rise (in inches) in 12 inches of horizontal run. Usually expressed as 3/12, 4/12, 5/12, etc., the pitch is a measure of the inclination of a truss member.

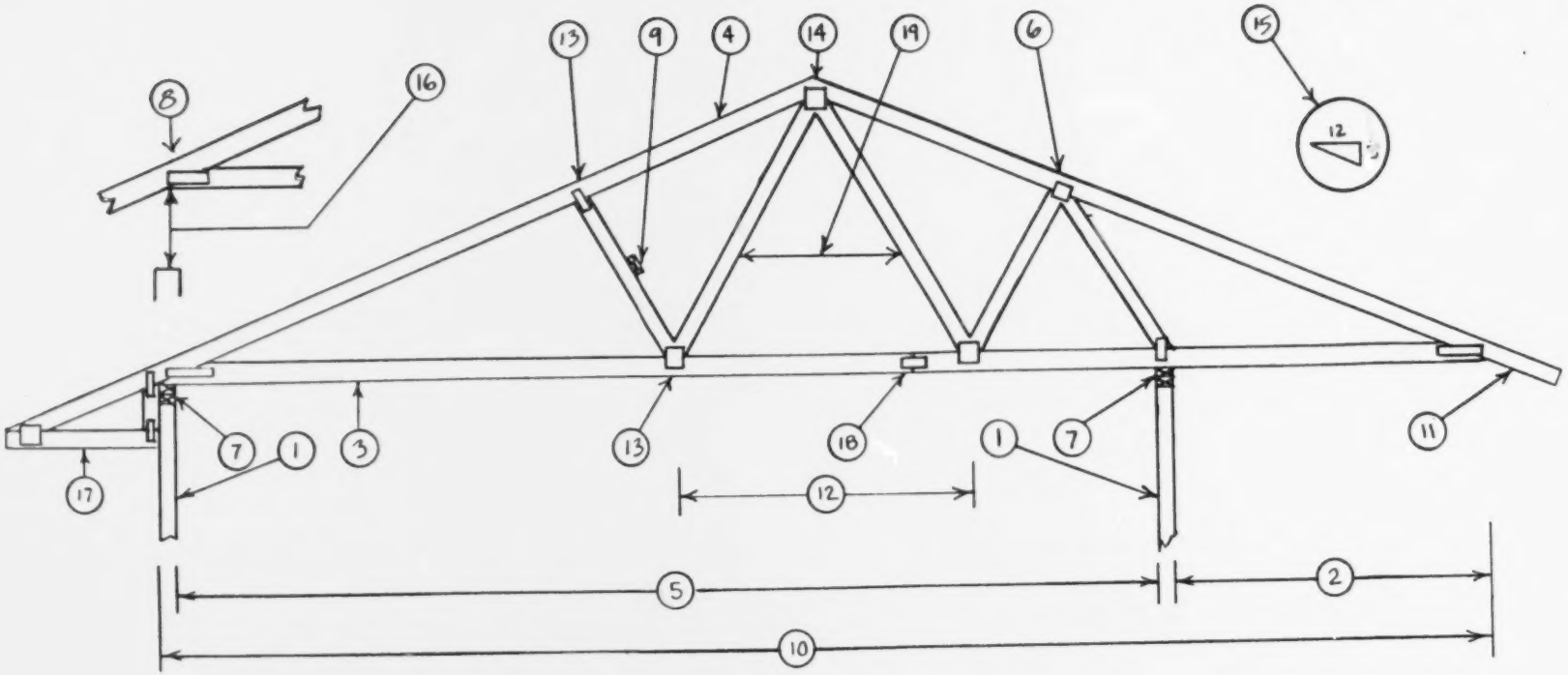


Figure 1

- Purlin—A horizontal member in a roof system which acts as a support for the decking. Purlins are generally placed perpendicular to roof truss chords to provide intermediate support for plywood deck, wooden shakes, etc.
- Reaction—The total load transmitted to the supports of a truss. The sum of all loads on the truss—live and dead—are equal and opposite to the sum of all forces acting at the supports.
- Scarf—(16) At the heel of the truss, the area of wood-to-wood contact between the top and bottom chord, measured horizontally.
- Soffit return—(17) Lumber filler placed horizontally from the end of the top chord overhang to the wall.
- Splice—(18) The point on the top or bottom chord at which two chord members are joined together via a connector plate to form a single member. May occur at a panel point or in a panel.
- Truss—An engineered prefabricated structural component within a roof system, made up of one or more triangles.
- Webs—(19) Members that join the top and bottom chords to form the triangular patterns that give truss action, usually carrying compression or tension stresses but no bending.

Equipment/Supplies
- Scaled (1"= 1'0") truss members
- Band saw
- Hot glue gun and glue sticks
- Posterboard for gusset plates
- Testing base

Introduction
In recent years engineered trusses have replaced standard roof framing in most residential construction. Roof trusses are designed to meet specific performance standards for a variety of building situations. Their efficiency and economy make trusses common components in both residential and commercial building construction.

In this activity students will design and build a roof truss to scale and test the strength of the truss using the testing device described in the activity. Data collected from the structural testing will be gathered and compared to that of other students.

Procedure
1. Begin by looking through the series of truss designs contained in the activity. Select a truss type that you would like to build and test. Note that it is advisable to work on only one design at a time.
2. Draw a pattern for your truss design using a span of 20'0" and a pitch of 5 /12. Use a scale of 1" = 1'0".
3. Cut the framing members as accurately as possible and glue the main components together using a hot glue gun. All joints should be neat and even. It should be noted that careful cutting and assembly of truss joints will yield stronger trusses.
4. Cut gusset plates from posterboard and attach them using the hot glue gun to both sides of the truss wherever a joint occurs.
5. Test the load-bearing capacity of the truss using the testing base provided by your instructor. The truss should be stressed until it fails. Use the formula below to record the efficiency rating of the truss.

Efficiency Rating = Live Load + Dead Load

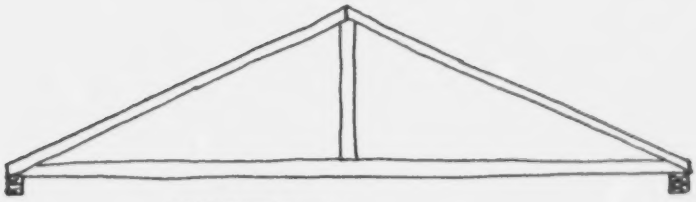
Safety Limit Factor = Efficiency Rating + 3

6. Record your testing data on the attached worksheet. Compare your results with others in the class.
7. Discuss as a group how some truss designs tested stronger than others and what effect differences between the designs might have had on their ability to support a load.
8. Write a summary technical paper in which you report your testing data. The technical paper should be written so that another student can duplicate the activity.
9. Prepare a display of your projects for other students to see.

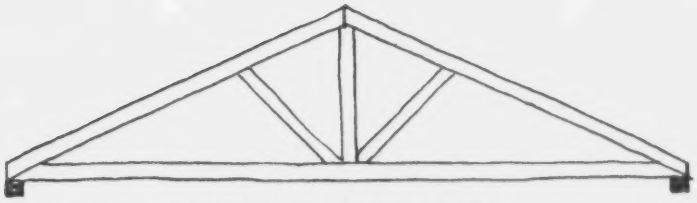
Evaluation

Evaluation will be based on your participation in the activity and on your written technical report.

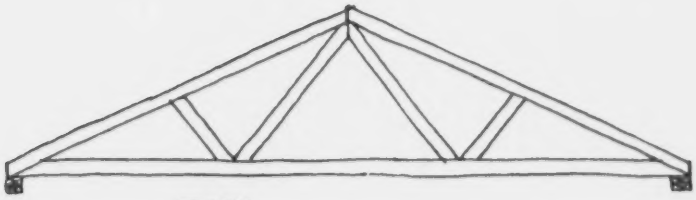
TRUSS CONFIGURATIONS



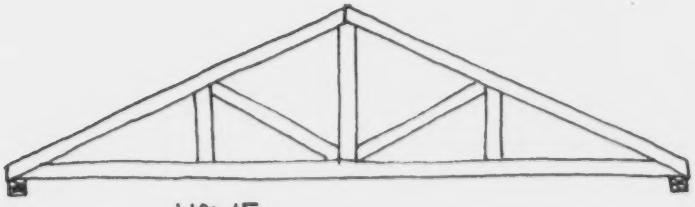
KINGPOST



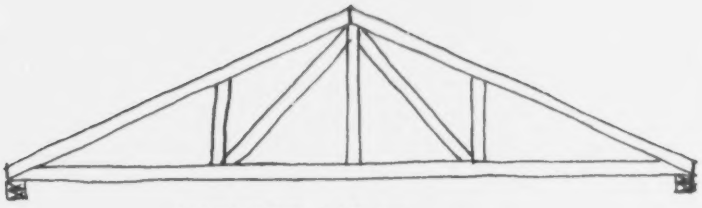
MODIFIED KINGPOST



FINK



HOWE



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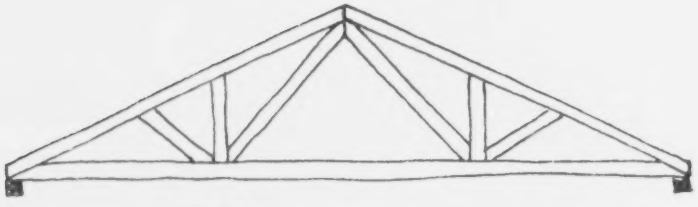
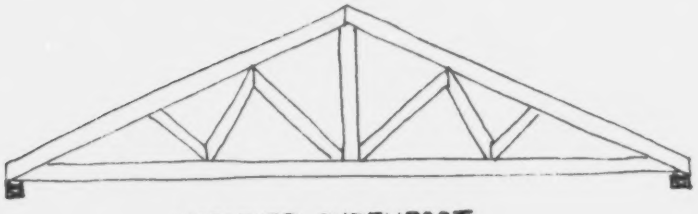
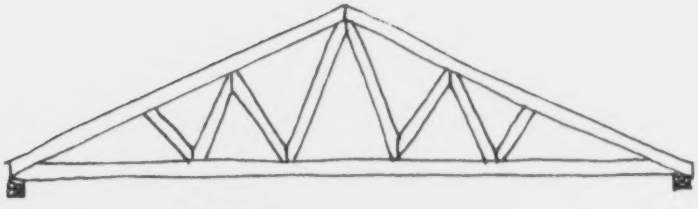


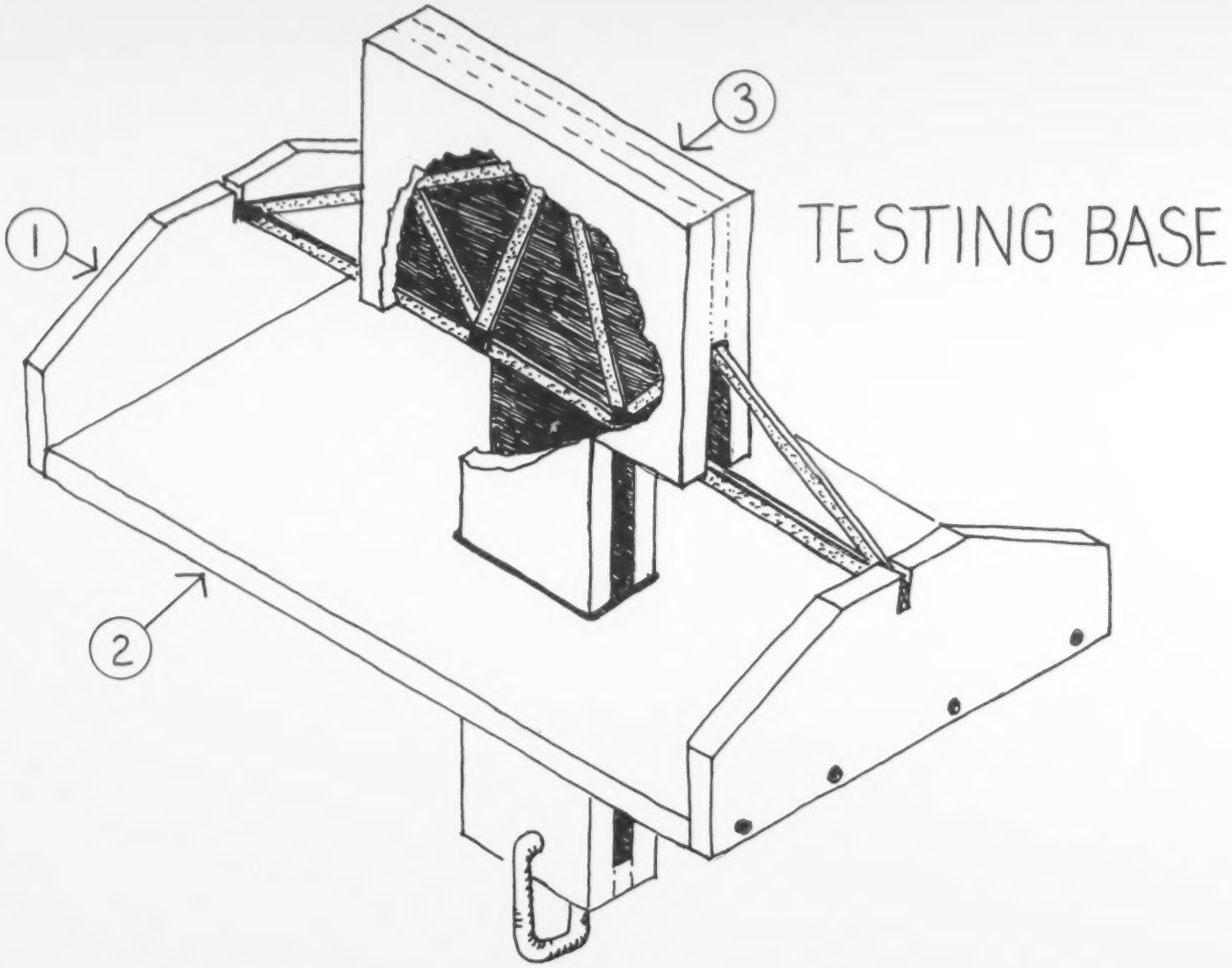
FAN



MODIFIED QUEENPOST

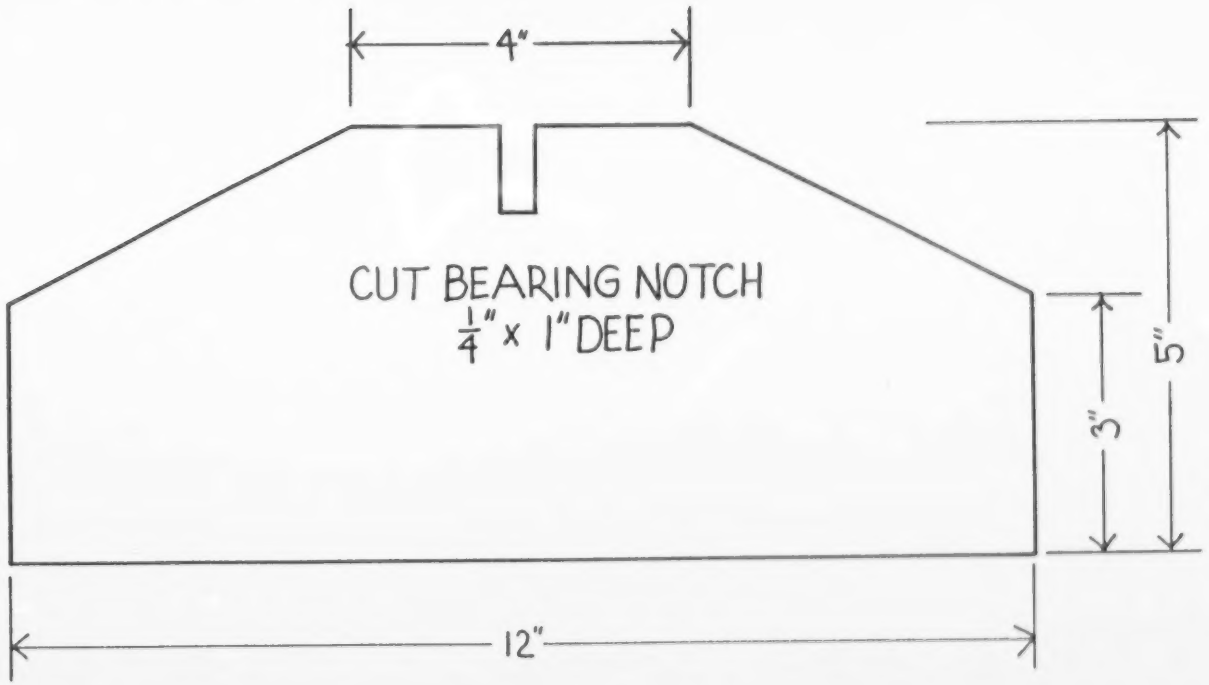


WARREN

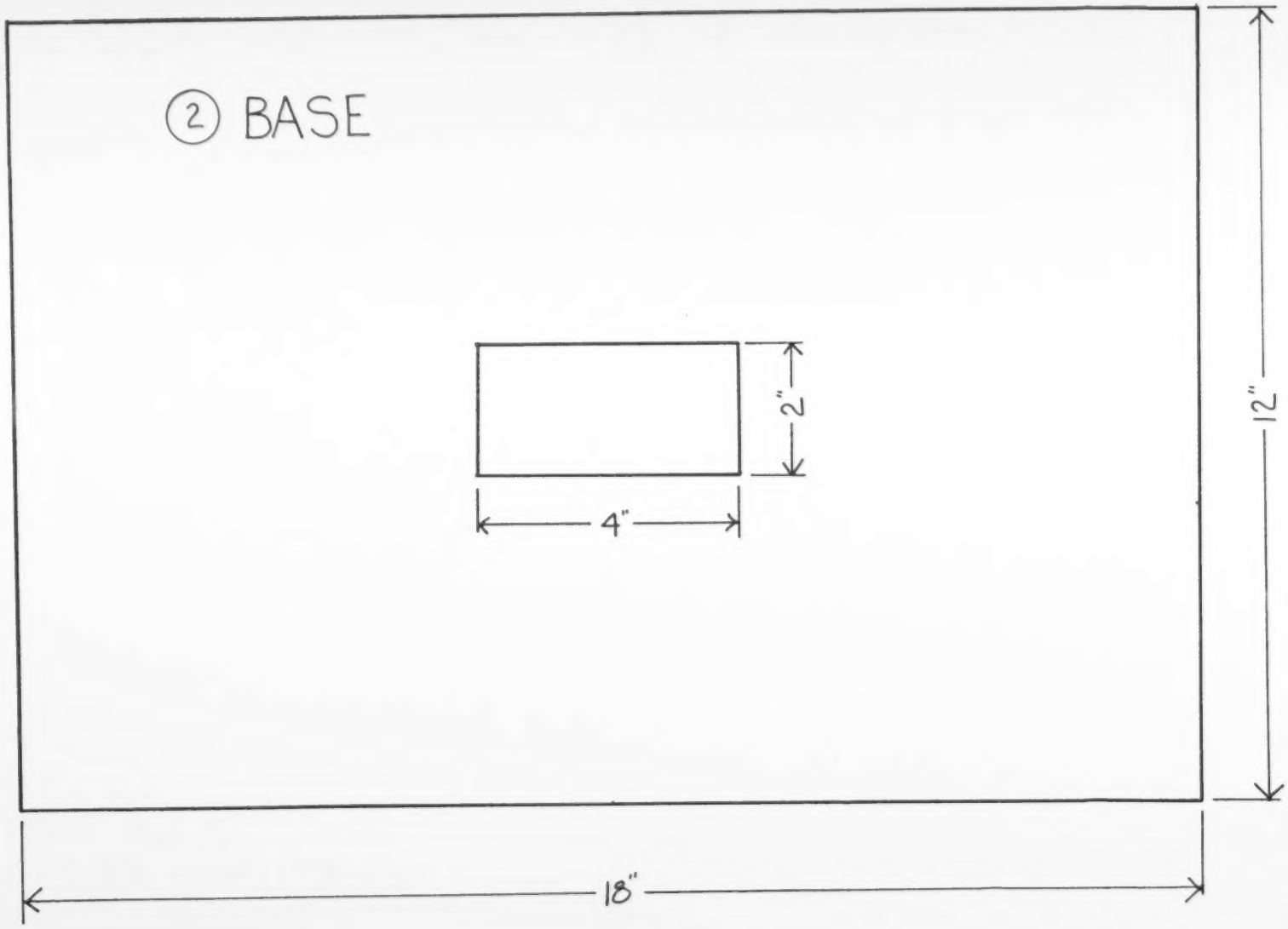


TESTING BASE

BEST COPY AVAILABLE



(1) END PIECE - 2 REQ'D



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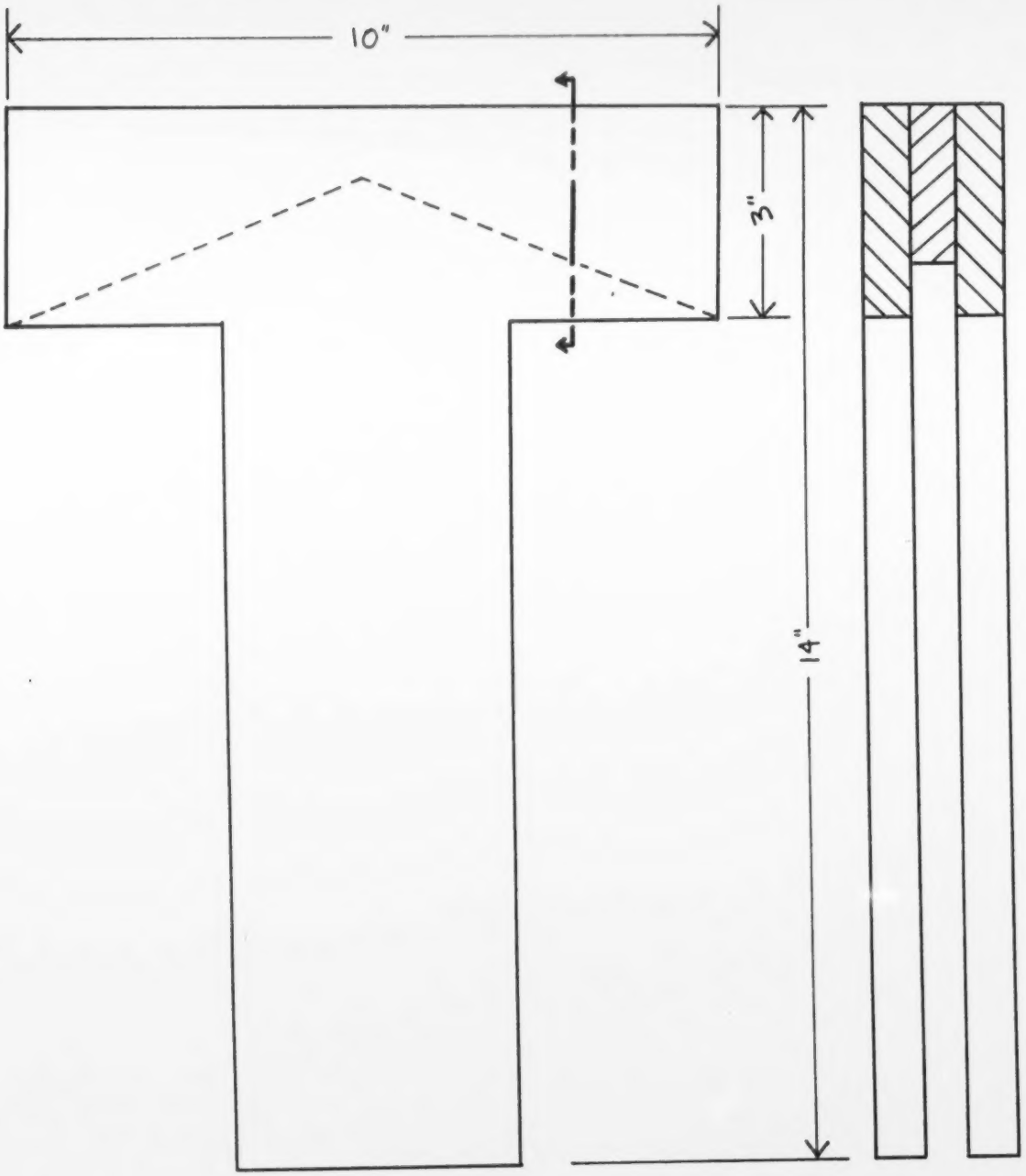
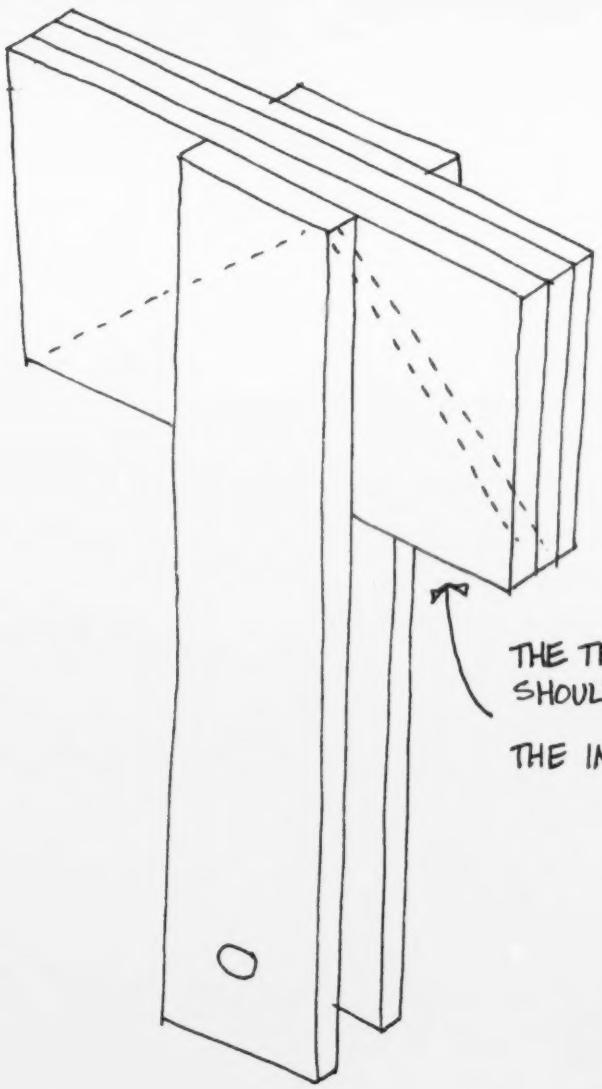


(3)

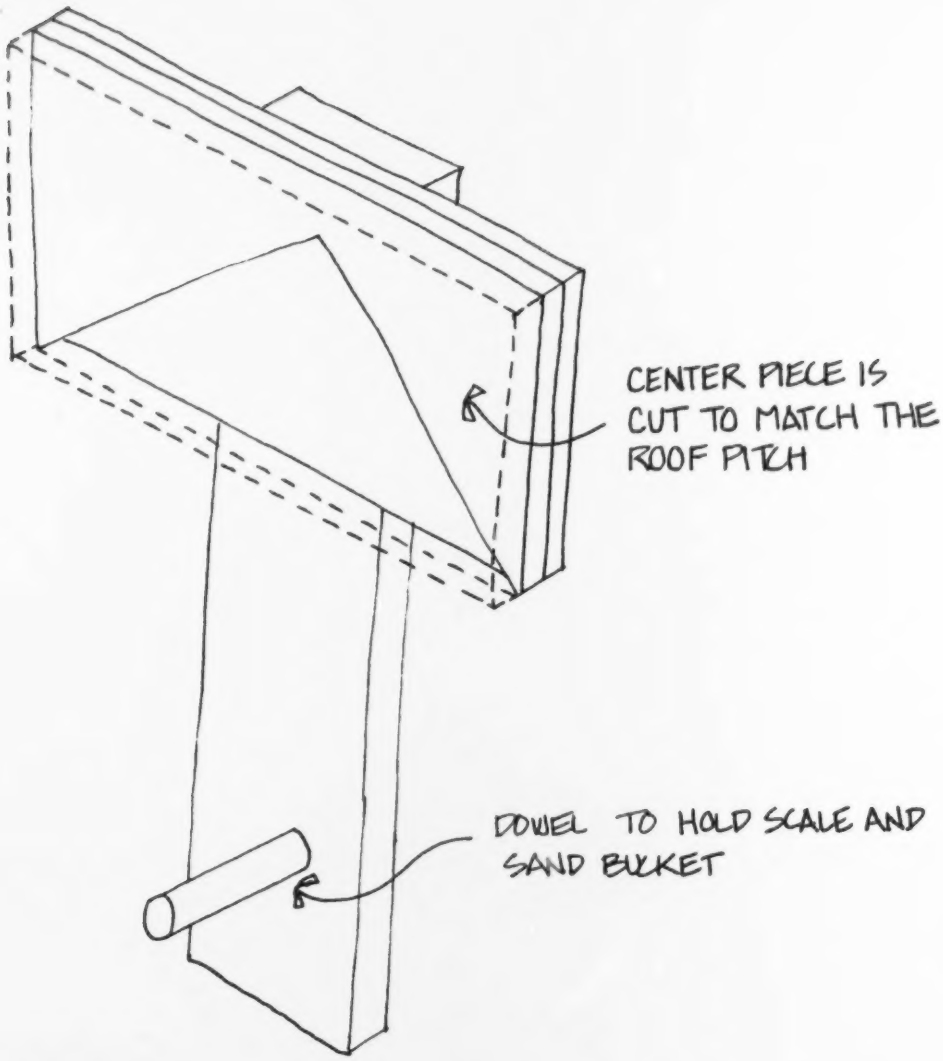
NOTE: ANGLE SHOULD MATCH SELECTED ROOF PITCH

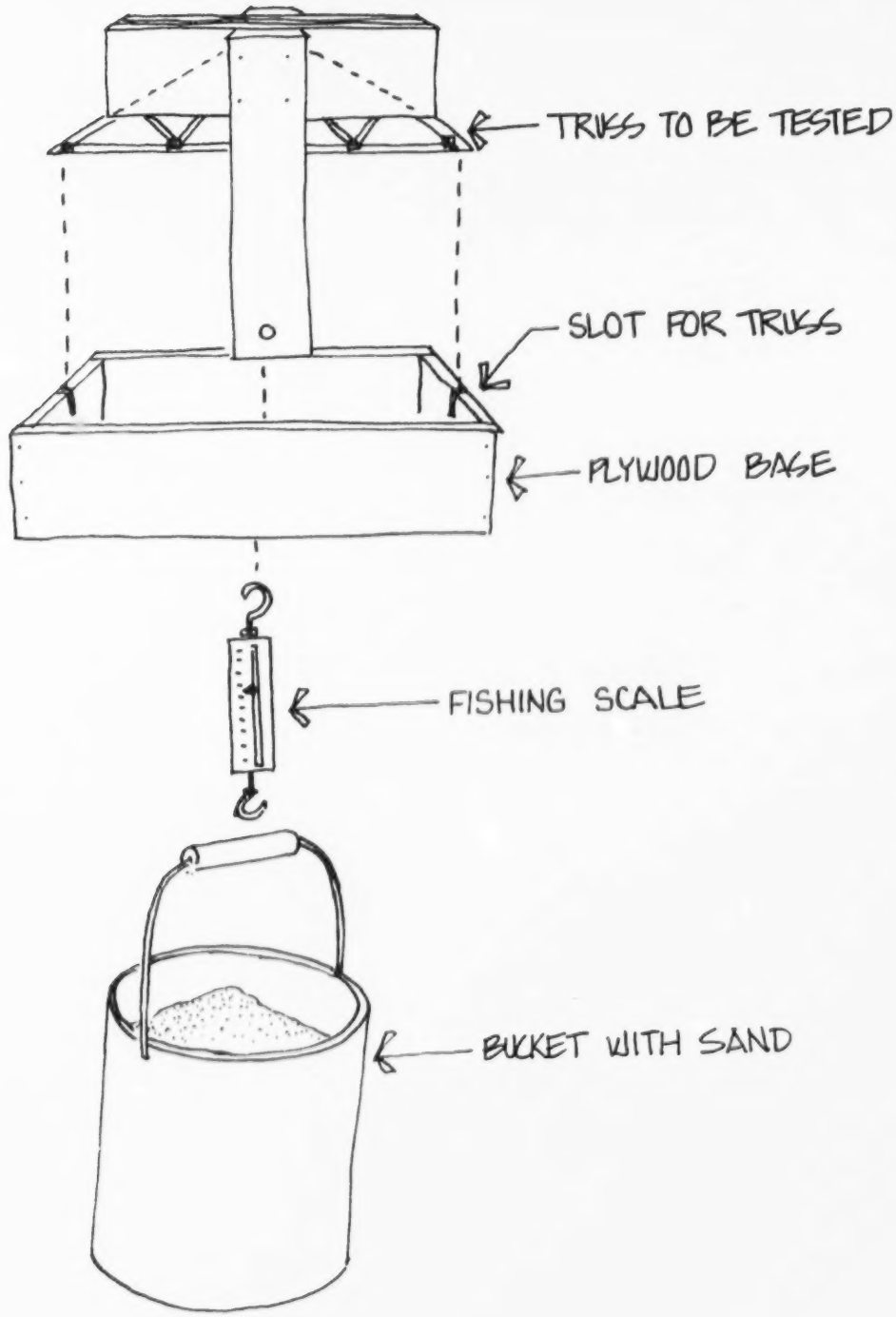
LIVE LOAD TESTER



USE 1/4" PLYWOOD

THE TRUSS TO BE TESTED SHOULD EASILY SLIP INTO THE INSIDE SLOT.


CENTER PIECE IS
CUT TO MATCH THE
ROOF PITCH
DOWEL TO HOLD SCALE AND
SAND BUCKET


TRUSS TO BE TESTED
SLOT FOR TRUSS
PLYWOOD BASE
FISHING SCALE
BUCKET WITH SAND

DESIGNING AND FABRICATING AN ALUMINUM CAN CRUSHER

Essential Elements: Common: 6-10
Specific: 2, 3, 6, 8-11
TAAS Objectives: Language Arts: RC 1-4

Activity Summary

This activity is intended to provide advanced-level students in Production Systems or Manufacturing Systems classes with a research and development project in which they design and fabricate an aluminum can crusher and test its effectiveness in a pilot study. Students will also report their findings in a short technical report.

Teaching Tips

1. Talk about the importance of recycling common materials.
2. Review safety procedures for using various tools and machines as necessary.
3. Have students research the existing can crushers that might be available through local hardware stores. Students should be encouraged to research existing designs before they spend any time designing their own device.
4. Discuss with your students the availability or limitations of both equipment and materials that may be used.
5. You may wish to establish your own set of design criteria rather than using the criteria discussed in this activity.

Instructional Strategy

- Encourage the use of creativity and imagination in the designing of this project. Review the instructional strategies section at the beginning of this manual for ideas in using creativity concepts.
- Use the discussion method of presenting this topic to students.
- The activity can be completed as either an individual or group project depending on the needs of your particular students.

Equipment/Supplies

1. Metal-cutting tools or equipment
2. Welding equipment
3. Measurement devices
4. Drawing board, T square, scale, paper, etc.
5. Metal
6. Miscellaneous hardware as needed
7. Other materials as needed

Evaluation Key

Evaluation of student performance on this activity should be based on participation in and completion of the project. Individual instructors may wish to include additional criteria as needed for their particular students.

Support Material

Teacher selected information manuals on equipment as needed

DESIGNING AND FABRICATING AN ALUMINUM CAN CRUSHER

Design, fabricate, and test your concept of a household aluminum can crusher.

Objectives

- To apply basic research techniques to locate and evaluate existing information related to a specific topic
- To solve a basic design and fabrication problem using established problem-solving techniques and creative thinking skills
- To design or improve a product or process to meet stated performance requirements

Vocabulary/Concepts Reinforced

- Specification—A written description in which precise details are stated.
- Performance standard—A written statement describing what a product is supposed to accomplish.
- Pilot study—The testing of a prototype against stated performance standards and specifications.

Equipment/Supplies

- Metal-cutting tools and equipment
- Welding equipment
- Measurement tools
- Drawing board, T square, scale, paper, etc.
- Metal for fabrication
- Miscellaneous hardware as needed

Introduction

Modern technology depends on the problem-solving skills of individuals at almost every level of product development. In some cases the design and testing of a new product or process are left up to the ingenuity of a single person, but in most cases the process of development demands the problem-solving skills of teams of individuals. Developing new products or processes is a vital part of modern technology and our industries need individuals who can solve developmental problems through creative problem-solving skills.

In this activity students will be asked to design a product based on a set of basic performance standards and specifications. Students will research existing products that perform the same function and study their acceptable and unacceptable characteristics as they apply to the design criteria. Students will then design and fabricate a pilot prototype which they will test for compliance with the design criteria. Upon completion of the testing, the product will be evaluated through a technical report to the class, and revisions to the design will be made accordingly. Additionally, a market survey may be completed in order to test the marketability of the product.

Performance Standards—This product must be able to crush standard aluminum cans to a thickness of no more than one inch. The "can crusher" must be able to be operated by a person using one hand. The device must deposit the crushed aluminum can from above into a standard five-gallon plastic paint bucket which can

be removed by one hand from under the device and transported away from the device.

Specifications—The device should meet the above performance standards as well as the following. The device should weigh no more than fifty pounds and fit into a space of no more than four square feet. Limit removable parts to one which must be able to be stored securely somewhere on the device.

Procedure

1. Divide your class into groups of three or four students and assign responsibilities based on the following list of procedures.
2. Begin by carefully reading and analyzing the performance standards and design specifications.
3. Research existing can-crushing devices and evaluate them against the design criteria.
4. You may use as many of the acceptable criteria as possible from an existing design without infringing on a patented or copyrighted design information.
5. Brainstorm ideas that your group thinks might work.
6. Create a set of sketches and analyze them for possible design solutions.
7. Pick one or two ideas and add more detail to your designs. Do not attempt full working drawings at this time, but make drawings with as much clarity and detail as possible in a sketch format.
8. Evaluate the detailed sketches for a possible solution to the problem.
9. Select one prototype design and complete a set of working drawings.
10. Estimate the required materials and complete a parts list.
11. Procure the required materials and begin your prototype layout.
12. Carefully construct your prototype and complete as much testing of the device as can be practically done as you go.
13. Complete the device and apply finishing details as necessary such as grinding, priming, and painting.
14. Have your instructor test the device for compliance with the stated design criteria.
15. Have someone who is independent of the class such as another teacher or a neighbor test the device for a specified period of time. Have that person complete an evaluation of the device and report these findings to the class.
16. If time permits, prepare and distribute a product market study to see whether or not your device is marketable.
17. If your design works, take orders, manufacture the can crusher, and sell enough to pay for the materials that you have used and make a small profit.

Evaluation

Instructor evaluation will be based on student participation in and completion of the activity.

ESTIMATING STRUCTURAL MATERIALS

Essential Elements: Common: 8, 9, 10
Specific: 1, 2, 5, 7, 11

TAAS Objectives: Language Arts: RC 1-5
Mathematics: C 1-5
O 1-4
PS 1-4

Activity Summary

This activity is intended for advanced-level students interested in either Construction Systems or Construction Graphics. The activity provides for students to follow a set of formulas developed to estimate quantities of structural materials typical of residential construction. Students will apply this estimating package to a completed set of floor plans. The activity helps reinforce the need for accuracy and completeness when making architectural drawings, as well as the need for careful calculation when estimating materials.

Teaching Tips

1. Read through the entire activity before releasing to students.
2. Provide the necessary "Materials Takeoff Estimate Sheet" included with this activity.
3. If you wish to simulate the actual conditions placed on contractors, give your students a "tight" time frame for completion of the activity.
4. If possible, have your students use a spreadsheet program on a personal computer to complete their estimate. You might also have them price out the cost of materials by calling a local lumberyard.

Instructional Strategy

- Use this activity as either a small group or individual problem-solving project.
- Use the activity to simulate the materials-estimating function of building construction. It can be applied to role playing or the simulation of operating a general contracting company.

Equipment/Supplies

1. Estimating Formulas sheet
2. Materials Takeoff Estimate Sheet
3. Computer with spreadsheet program, if available
4. Calculator
5. Set of residential house plans, including floor plan and elevations
6. Architect's scale
7. Scratch paper

Evaluation Key

Evaluation of this activity should be based on the student's participation in and completion of the project. If the activity is to be part of a larger project, evaluation should be adjusted accordingly.

ESTIMATING STRUCTURAL MATERIALS

Use a set of estimating formulas to estimate the quantities of structural building materials needed to construct a house.

Objectives
- To read a set of architectural plans and prepare an accurate materials estimate from the calculations

Vocabulary/Concepts Reinforced
- Takeoff—The preparation of a list of building materials needed to build a structure.
- Estimate—The calculated quantity of materials needed to complete a building construction project.
- Formula—The defined calculation needed to determine a specific quantity.

Equipment/Supplies
- Estimating Formulas sheet
- Materials Takeoff Estimate Sheet
- Calculator
- Complete set of architectural plans, including floor plans and elevations
- Computer with spreadsheet program, if available
- Architect's scale
- Pencils and scratch paper

Introduction
Materials estimating is an important and often critical function of the general contracting business. Careful calculation of the building materials needed to construct a house often determines how the contractor prepares his bid on a project. Additionally, the contractor needs to control his own construction costs by insuring that he orders both the correct sizes and quantities of materials. Accurate estimating is therefore a vital component of the general contracting industry.

In this activity students will carefully study a set of blue prints for a typical residential construction project. These plans can be produced by students or can come from another source. This activity is particularly useful in helping students realize the importance of accuracy in drawing a set of plans, as well as the need for careful measurement and materials calculation.

Procedure
1. Begin by studying the attached Estimating Formulas sheet. These formulas will provide an accurate estimate of quantity with very little waste material.
2. Carefully apply the formulas to the set of plans that you are using and complete the Materials Takeoff Estimate Sheet.
3. If time and equipment permit use a spreadsheet program and a personal computer to price out the materials list.

Evaluation
Instructor evaluation will be based on participation in and completion of the activity.

ESTIMATING FORMULAS

ITEM	MEASUREMENT
1. Studs	Lf O/S & I/S Walls—1 Stud per Lf (Note: Ht. & Size)
2. Plates	If house is 1-story, multiply Lf of all walls by 5. If house is 2-story, multiply Lf of all walls by 6.
3. Wind Braces	For 8' walls use 1x4-12' for taller walls use 1x4-14.' Use 4x8 15/32" CDX for short corners.
4. Plate Felt	Lf of O/S walls + 70'
5. Moistop	2-3 rolls—Extra large house use 4 rolls
6. Beams/Posts	Watch details.
7. Headers	2x12 O/S walls and cased openings—2x6 I/S walls 3-story houses—bottom floor all 2x12s
8. Garage Door	2x6 for siding—2x8 for rock or brick
9. Furr Downs	10% of sq. ftg. of house 2x4 Utility SPF (8-16)
10. Floor Joists	2x12 #2YP (Watch Specs) or 2x10 #2YP. Add 3x width for blocking and ends.
11. Subfloor	3/4" T&G Underlayment—Sq. ftg. of 2nd floor + 30
12. Adhesive	1/4 x number of sheets of underlayment (PL 400)
13. Stairs	2x12 #2YP Stringers—2x10 #2YP steps + 3/4 ACX
14. Ceiling Joists	2x6 #2YP or Fir. (Garage 2x8 w/disp. stairs)
15. Rafters	Usually 2x6—2x8 #2YP (Watch Specs.)
16. Ridge	Use next larger 2X material
17. Purlin & Braces	5% of sq. ftg. of house 2x6—double for 2x4
18. Fascia—Grooving	Lf of Fascia x 1.4 (Watch Specs for smooth or rough and size)
19. Shingle Mold	Lf of fascia x 1.4 (usually 1x2 RSC)
20. Soffit	Lf of fascia divided by 16 for 2' overhang—watch details for covered porches
21. Channel Groove	1/2 the number of sheets of soffit
22. Soffit Vents	Usually 8"x16" each. Lf. fascia divided by 8, round up
23. Gable End Vents	See details.
24. Roof Decking	Sq. ftg. of roof plus 32 sq. ft. for CDX.
25. Plyclips	12" OC = SF x 1.5, 16" OC = SF x .8, 24" OC = SF x .6
26. Roofing Felt	Sq. ftg. of roof + 400 sq. ft. for #15 and + 200 sq. ft. for #30.
27. Shingles	(Watch Specs.) Sq. ftg. of roof + 100 sq. ft. Sq. ftg. x 1.25 for Cal Shake type material
28. Ext. Sheathing	Sq. ftg. of surface area x 1.3
29. Siding	4x8—Sq. ft. + 60 divided by 32 = number sheets 1x4—Sq. ft. x 3.2 = Total Lf. 1x6—Sq. ft. x 2.2 = Total Lf. 1x8—Sq. ft. x 1.2 = Total Lf. 1x8 L&G—Sq. ftg. x 1.4 = Total Lf. 1x10 L&G—Sq. ftg. x 1.3 = Total Lf. 6" Lap—Sq. ft. x 2.2 + 16' = Total Lf. 8" Lap—Sq. ft. x 1.8 + 16' = Total Lf. 12" Lap—Sq. ft. x 1.2 = 16' = Total Lf.
30. Exterior Trim	Usually 1x4, 1x2, 1x6 (Watch Specs) # doors, windows, and corners x 25 = Total Lf.

MATERIALS TAKEOFF ESTIMATE SHEET

NO.	ITEM	DESCRIPTION	QTY.	COST	EXTENSION
1.	Studs				
2.	Plates				
3.	Wind Braces				
4.	Plate Felt				
5.	Moistop				
6.	Beams				
7.	Posts				
8.	Headers				
9.	Garage Door Trim				
10.	Furr Downs				
11.	Deadwood				
12.	Floor Joists				
13.	Subfloor				
14.	Adhesive				
15.	Stairs				
16.	Ceiling Joists				
17.	Rafters				
18.	Ridge				
19.	Purlin & Braces				
20.	Fascia				
21.	Shingle Mold				
22.	Soffit				
23.	Channel Groove				

NO.	ITEM	DESCRIPTION	QTY.	COST	EXTENSION
24.	Soffit Vents				
25.	Gable End Vents				
26.	Roof Decking				
27.	Plyclips				
28.	Roofing Felt				
29.	Shingles				
30.	Sheathing				
31.	Siding				
32.	Exterior Trim				

COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, Department of Health, Education and Welfare.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964: EXECUTIVE ORDERS 11246 and 11375; TITLE IX 1973 EDUCATION AMENDMENTS: REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulation by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs of activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.